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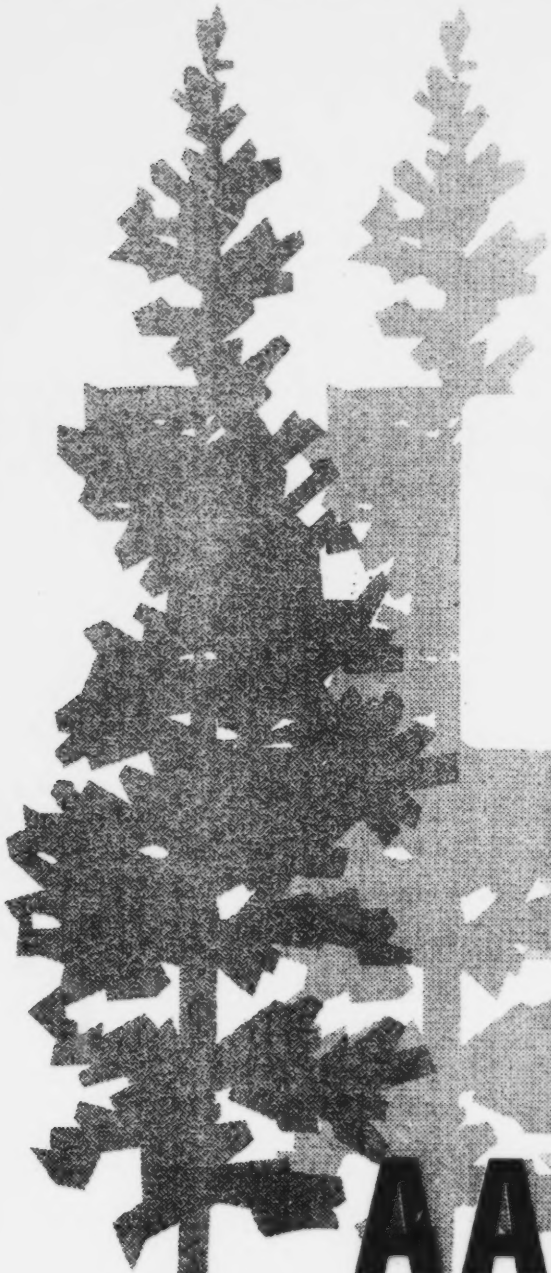

Cranbrook TSA
Problem Forest Types
Targeted Inventory

Technical Report MIT-006

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Cranbrook TSA
Problem Forest Types
Targeted Inventory

Technical Report MIT-006

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EXECUTIVE SUMMARY

In the face of decreasing harvest levels, it is incumbent on forest managers to re-evaluate all assumptions upon which the harvest levels are based. In the Cranbrook TSA there is a significant area occupied by overstocked, small diameter, and or short timber (problem forest types or PFTs) which is currently not considered to contribute to the harvesting land base. The Cranbrook TSA Timber Supply Review showed that harvest levels were sensitive to changes in operable area. These facts make investigation of the PFTs a high priority.

An inventory upgrade targeted at PFTs has been undertaken to provide reliable information on areas, stand characteristics and volumes of these stands. Seven PFT classifications identified in the Timber Supply Review have been adopted as sample populations for this inventory project. The following objectives have been met:

- Undertake sampling of PFTs in an unbiased manner;
- Use the results to develop an inventory attribute adjustments strategy;
- Reassess subject stands for classification as problem forest types; and
- Develop new strategies for determining the contribution to timber supply that these stands might make.

Selected in an unbiased manner from the PFT stands across the total Cranbrook TSA land base were 154 polygons. Of these, 137 polygons were sampled (with replacement) with a cluster of five fixed area cruise plots. Compiled cruise summaries represent 'truth' values for the evaluation of the accuracy of the forest inventory for seven strata as defined in the sampling plan (Appendix I).

Ministry of Forests (MOF) forest inventory estimates of stand attributes and computed site indices and volumes were compared to compiled cruise 'truth' values. This allowed a determination of the accuracy of the PFT subset of the existing inventory. The table below presents age, height and volume comparisons between inventory and 'truth' values. Those shown to be significantly different are shaded.

Summary of accuracy – problem forest types subset of the Cranbrook TSA forest inventory

Problem Forest Type	Mean Inventory Values			Mean Ground/Cruise Based Values		
	Age	Height	Volume	Age	Height	Volume
PFT #2 (Pl age >= 41years, height < 10.5m)	55	9.3	19.0	55	14.5	82.7
PFT #5 (Fd, Py 41-60 years, 10.5-19.4m)	56	15.7	74.3	59	16.9	97.9
PFT #6 (Fd, Py 61-80 years, 10.5-19.4m)	74	17.7	96.2	65	17.0	103.7
PFT #7 (Fd, Py >80 years, 10.5-19.4m)	97	17.5	99.2	82	16.7	82.8
PFT #12 (Pl 41-60 years, 10.5-19.4m)	58	16.2	115.9	59	17.2	154.7
PFT #13 (Pl 61-80 years, 10.5-19.4m)	70	16.7	125.7	64	18.2	142.6
PFT #14 (Pl >80 years, 10.5-19.4m, stocking class 4)	107	16.3	109.6	96	16.6	168.4

Where inventory volumes predicted by the Variable Density Yield Prediction System (VDYP) were found to be significantly different from cruise compiled values (shaded in the table above), the most appropriate method of improving those estimates was identified. The adjustment strategy was implemented across the whole TSA land base and PFT contribution recalculated. The new distribution of PFTs in relation to the rules used in Timber Supply Review I to define contribution to the net harvesting land has implications for timber supply. The possible impacts of the redistribution are provided in the table below.

PFT contribution to net harvesting land base

PFT Type	TSR I % Net Down	Total Operable Area (ha)	PFT Contribution under TSR I		PFT Attribute and Volume Adjustments	
			Area (ha)	Volume (m3)	Area (ha)	Volume (m3)
2	80	2,676	535	5,426	2	13
5	10	7,288	6,559	453,309	9,012	817,838
6	20	13,923	11,138	903,478	12,540	1,047,666
7	40	14,354	8,612	789,007	5,926	446,233
12	15	31,691	26,937	2,899,912	42,690	6,343,512
13	25	46,203	34,652	4,351,266	22,839	3,655,234
14	50	13,411	6,706	1,017,068	6,726	1,810,262
Total		**129,546**	**95,140**	**10,419,467**	**99,734**	**14,120,757**

The adjustment strategy increases the net land base by 4,594 ha (4.8%) and indicates that there is available a volume of 3.7 million metres over and above that previously believed (an increase of 35% on the PFT land base).

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APPENDIX II - FIELD METHODOLOGY

APPENDIX III - DETAILED ANALYSIS RESULTS

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APPENDIX V - SAMPLE LOCATION MAPS

1. BACKGROUND AND OBJECTIVES

Problem forest types are stands that are physically operable and exceed low site criteria yet are not currently utilized or have marginal merchantability. There is uncertainty surrounding the definition and extent of problem forest types in the Cranbrook TSA and how they might contribute to the mitigation of reductions in harvest level. An inventory upgrade targeted at PFTs was required to provide reliable information on areas, stand characteristics and volumes. This data can now be used to improve management and planning in the TSA.

The timber supply review of Cranbrook TSA indicated sensitivity to changes in land base. Areas currently defined as problem forest types are one opportunity to expand the net harvesting land base.

The Ministry of Forests initiated this project to re-inventory stands currently assessed as problem forest types. A sampling plan was prepared by the MoF (see Appendix I) which called for data collection in 154 PFT stands throughout the Cranbrook TSA.

Timberline was retained to develop, co-ordinate and implement the project. The objectives were to:

- Undertake sampling of PFTs in an unbiased manner;
- Use the results to develop an inventory attribute adjustments strategy;
- Reassess subject stands for classification as problem forest types; and
- Develop new strategies for determining the contribution to timber supply that these stands may make.

2. METHODOLOGY

2.1 Project Initiation

An initial teleconference with the AAC Mitigation Team Leader and the TSA Steering Committee was used to confirm the information necessary to prepare a detailed project plan. Timberline took delivery of project materials including digital map data and the sampling plan prepared by the Resources Inventory Branch which appears in Appendix I.

The MoF provided the forest inventory data for the Cranbrook TSA in IGDS format. Timberline translated the data to Arc/INFO format and prepared the necessary forest inventory attribute data base and mapping products.

Deliverables from this phase were:

- A project plan including the sampling plan prepared by Resources Inventory Branch;
- A TSA overview map at a scale of 1:125,000 displaying roads, the 1:20,000 BCGS map grid and the polygons to be sampled. (A revised version of the same maps which reflect the final polygon list can be found in Appendix V);
- 1:10,000 scale work maps for all sample polygons for layout of field work;
- Work maps with cluster polygon locations mapped; and
- Air photos for confirmation and recording of plot locations.

Aerial photograph coverage was confirmed and photos were ordered from the Maps BC photo library. Cluster access was confirmed at the same time.

2.2 Invitation to Quote Process

Based on results of the first phase, a detailed invitation to quote (ITQ) was prepared and distributed to potential field contractors. The bidder list was provincial in scope and included contractors as recommended by MoF Regional Inventory Foresters. The ITQ indicated flexibility in the volume of work to which the contractor could commit in order to remain flexible with regard to limited contractor availability and funding uncertainty. Timberline participated in reviewing bids, awarded the work, and prepared the necessary contract and project materials.

Three contractors were awarded portions of the work. The contracts were executed between the field contractors and the Ministry of Forests.

2.3 Sampling Plan

The full sampling plan is provided in Appendix I.

Drawn from the sampling plan is Table 2.1 that defines the sample size by PFT. Problem forest types are as defined in the Timber Supply Review (TSR) for Cranbrook TSA. Area of each PFT in the current inventory is provided to facilitate the evaluation of the relative importance of each. Percent exclusion refers to the way the PFT was treated in the TSR netdown process. Each PFT is treated as a separate sub-population and an allowable sampling error of 15% was the basis for determining the approximate sample size to be allocated. Coefficient of variation in percent (CV %) is provided to assess the amount of variation in the volume predicted by the inventory.

The selection of polygons to be sampled was based on the principles of probability selection. The target strata were defined as the PFT types discussed above and drawn from the entire TSA land base. A complete list for each stratum was created to constitute the sampling frame for the target populations. Samples were systematically selected from those lists with probability proportional to area of polygon.

Table 2.1 Definition of the sample size

PFT #	Area (ha)	Definition	Inventory Type Group	Age Class	Height Class	% Exclusion	Sample weights	Coefficient of Variation %	Sample Size
2	2,744	Lodgepole pine age>=41 ht<10.5	28-31	>2	1	80	110	91.7	25
5	6,870	Fir, Py 41-60yrs 10.5-19.4m	1,5-8 & 32	3	2	10	344	44.6	20
6	15,426	Fir, Py 61-80yrs 10.5-19.4m	1,5-8 & 32	4	2	20	701	35.3	22
7	12,066	Fir, Py >80yrs 10.5-19.4m	1,5-8 & 32	>4	2	40	483	30.5	25
12	37,553	Lodgepole pine 41-60yrs 10.5-19.4m	28-31	3	2	15	1707	34.6	22
13	46,929	Lodgepole pine 61-80yrs 10.5-19.4m	28-31	4	2	25	2346	25.9	20
14	3,099	Lodgepole pine >80yrs 10.5-19.4m	28-31	>4	2	50	155	26.6	20
Total	**124,687**						**5846**		**154**

2.4 Sample Replacement

In case replacement was required, the MoF provided a list of alternate sample polygons that were selected by PFT strata in the same manner as the original samples.

Six samples were wholly or partly harvested and required replacement. Replacements were used where logging disturbed more than 50% of the polygon to be sampled. This was considered a balance between the requirement for replacement and the degree to which the area proportional sampling methodology was compromised.

In the case that the polygon was retained in the sample but the pre-determined cluster location was logged, the cluster was relocated using the same unbiased methodology as the original layout. Mapping was kept up-to-date as polygons were replaced, with new materials provided to the sub-contractors.

Table 2.2 summarizes the extent to which replacements were required. Six samples, which had been harvested, were replaced. One helicopter access sample was replaced due to the lack of a safe drop-off spot. Two samples were inadvertently located in private land and park property and required replacement. Twelve samples were not collected due to poor access, snow conditions or too many void plots. Materials for five samples were lost after collection. These seventeen samples were not replaced due to a shortage of time as the field season drew to a close.

Table 2.2 Report of replacements necessary

	Replaced			Not Replaced	Materials
PFT Type	Logged	Safety/Access	Private/Park		Lost in Transit
PFT #2	2			3	3
PFT #5		1		2	
PFT #6	1			1	1
PFT #7	2		2	2	
PFT #12				2	
PFT #13				1	1
PFT #14	1			1	
Total	**6**	**1**	**2**	**12**	**5**

2.5 Field Methodology

Three sub-contractors, under direction of a Timberline on-site project manager, undertook collection of the data. The on-site manager was responsible for field contractor liaison and quality control. The manager accompanied contractors in the field for an initial training day to ensure appropriate and consistent methodology was used. Field methodology is described in detail in Appendix II.

Methods were based on MoF Valuation Branch Cruising Standards. Plot structure and data collection procedures were as per the Resources Inventory Branch Inventory Audit Sampling Standards and Procedures (January 17, 1997) except as noted in Appendix II. Custom tally cards were used to aid in complete collection of non-standard items and to ensure consistent format across subcontractors.

2.6 Quality Control

Data collected in the process of this project is for use in the next round of timber supply analysis (TSR 2). Use of the data for that purpose is contingent on high confidence in the accuracy of the data. The importance of quality and consistency to this project was made clear to all contractors.

One hundred percent of the field cards were office checked and ten percent of the plot clusters were quality checked in the field. Field inspections used current MoF procedures and standards for measurement and acceptance.

Quality control requirements were strictly applied. The data can be considered to be of high quality.

All project materials (air photos, plot cards, top height compilation sheets, location maps, access notes) will be stored at the Cranbrook Forest District office.

3. INVENTORY DATA PREPARATION

The forest inventory for the Cranbrook TSA was provided to Timberline by the MoF. Spatial graphics data in IGDS format and the associated forest cover attribute data was translated to Arc/INFO format.

The sample polygon list as determined in the sampling plan, and as updated as replacements were made, was merged with the inventory. The various map products described above were created with this data.

An Informix database was created from the attribute data. Existing inventory polygon data was summarized. This data set is the basis for the inventory analytical work described below.

The BATCHPROCESS functionality of the MoF model Variable Density Yield Prediction (VDYP) was used to project the inventory to 1997 and estimate polygon volumes. VDYP batch was also used to calculate site indices and volumes for ground attribute analyses discussed in Section 4.

4. FIELD DATA COMPILATION

Samples were received in the Timberline office, sorted and rechecked. Compilation details were finalized and all cards were keypunched and the raw data stored. Sampling is of forest cover polygons. Plots deemed to fall out of the polygon are dropped from compilation as are void plots on roads deemed to represent a long term area reduction from the polygon but too small to be removed as a forest polygon itself.

Field data was compiled according to MoF standards and to three different utilization standards:

- Special products and pulp compilation - 7.5 cm diameter breast height outside bark (dbhob), 7 cm top, 3m minimum length all species;
- Close utilization compilation - 12.5 cm dbhob, 10 cm top, 3m minimum length all species; and
- Current utilization compilation - 12.5 cm dbhob for Pine, 17.5 cm for other species, 10 cm top, 3m minimum length.

Plots were also compiled to the PFT strata level. While this is less appropriate for PFTs with a wide age range, the strata wide piece size distribution is of interest.

Top-height-based estimates of potential site index were also compiled. It is of interest to compare these to site index values based on current inventory and compilation heights.

Hard copy compilation reports will be stored with other project materials in the Cranbrook Forest District office.

5. INVENTORY EVALUATION

Inventory estimates of stand attributes and computed site indices and volumes are compared to compiled cruise 'truth' values. This section provides a summary of observations from those comparisons, a determination of the accuracy of the PFT subset of the existing inventory. A full listing of data, comparison statistics and graphic representations of the relationships can be found in Appendix III.

Where inventory volumes predicted by VDYP are found to be significantly different from cruise compiled values, the intention is to identify the most appropriate method of improving those estimates. The adjustment could be made in one of several ways; linear or non-linear regression; applying a correction based on the ratio of the two mean values; or correcting by the difference between the means. The latter two options are non-parametric; that is, they make no assumptions as to the data. Where correlation is strong, and differences determined to be significant, regression is likely to provide a superior result. Where significant differences are seen but the relationship is not particularly linear, one of the ratio adjustment method or the difference in means method may be preferred. The ratio of means adjustment is in fact a linear regression with the intercept forced to be zero.

The following notes apply to all tables in this section:

- Volumes are net decay waste and breakage, utilization level 12.5 cm.;
- Ground attribute volume is predicted by VDYP based on ground based input attributes;
- Inventory Volume is predicted by VDYP;
- Field based age and height are top heights;
- Field volume is compiled from cruise data;
- Ratio is ground over inventory;
- Correlation of 1 or –1 represents a perfect correspondence between x and y co-ordinates; and
- An absolute t-test value larger than the t-statistic indicates significant difference.

Results for all seven PFTs can be found in the sections below. More detail is provided in the case of PFT #2. This is to give the reader a more complete understanding of the process used in evaluating the results and determining the adjustment strategy. Full data for all PFTs can be found in Appendix III.

5.1 PFT #2 Results

Although twenty samples were available to contribute to the analysis of PFT #2, only 19 were used as one was clearly miss-located by the field crew. Tables 5.1 and 5.2 provide data and comparison summaries.

Table 5.1 Data summary PFT #2

	Inventory Data			Top Height Plot Data		Net Volume (m^3/ha)	
	Age (years)	Height (m)	VDYP Net Volume (m^3/ha)	Age (years)	Height (m)	Compiled Cruise	VDYP Ground Attribute
Mean	55.37	9.28	18.19	54.58	14.48	82.74	104.03
Standard deviation	7.33	2.86	30.48	11.05	2.80	48.49	38.16
Sampling error %	6.4	14.8	80.7	9.8	9.3	28.3	17.7
Upper confidence interval	58.90	10.66	32.88	59.91	15.83	106.11	122.43
Lower confidence interval	51.83	7.90	3.51	49.25	13.14	59.36	85.64

Note: 95% significance level.

Table 5.2 Inventory comparison summary PFT #2

	Inventory	Field Based	Ratio	Correlation	T-test
Total age (years)	55.37	54.58	0.9857	.2316	-0.48
Total height (m)	9.26	14.48	1.5610	.3615	7.44
Net volume (m^3/ha)	18.19	82.74	4.5473	.0168	17.87

Note: t-statistic = 2.101 (an absolute value greater than the t-statistic indicates a significant difference).

The data demonstrates no significant difference in age estimates between the inventory and field values. Height demonstrates significant difference and exhibits some linearity. Site index, although not shown on the tables above (please see Appendix III), also demonstrates a significant difference but no linear relationship. Differences in volume between VDYP inventory predictions and compiled cruise data are large and significant.

Although the comparison data is not shown above, ground attribute volume demonstrates a significant difference from compiled volumes with some linearity. This indicates some residual error due to VDYP modeling.

Volume prediction is shown to be inadequate. Recommended is an adjustment to inventory heights.

Table 5.3 provides descriptive statistics for adjusted heights based on ratio of means, difference-of-means, and linear regression methodologies. One can see that the means of the adjusted values are equal (and match the mean of the field value). The regression estimate results in the smallest confidence error and tightest confidence interval.

Table 5.3 PFT #2 height adjustment results

	Ratio Adjustment (*1.5610)	Difference in Means (+5.2 m)	Linear Regression (*.354+11.199)
Mean height	14.48	14.48	14.48
Standard deviation	4.46	2.86	1.01
Sampling error %	14.8%	9.5%	3.4%
Upper confidence interval	16.63	15.86	14.97
Lower confidence interval	12.33	13.10	14.00

The effect of the various methods in changing inventory heights is clearly described by the following figures.

The regression adjustment results in a stronger relationship between ground based top height and inventory height. This will be the case when the relationship between unadjusted inventory values and ground based top height has some linearity.

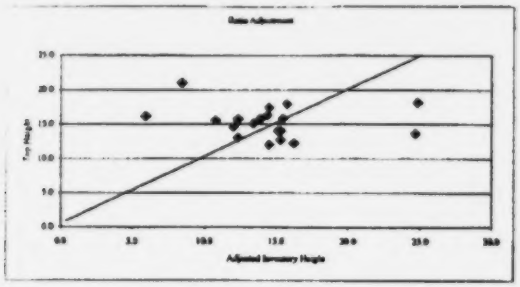


Figure 5.1 Ratio adjustment of heights – PFT #2

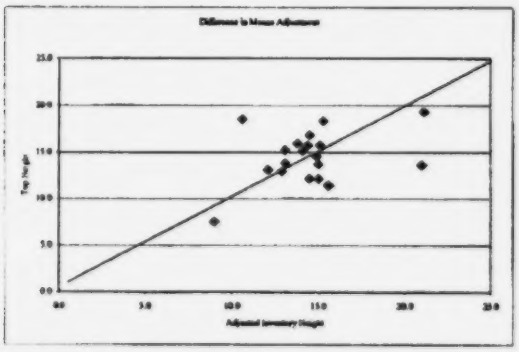


Figure 5.2 Difference in means adjustment of heights – PFT #2

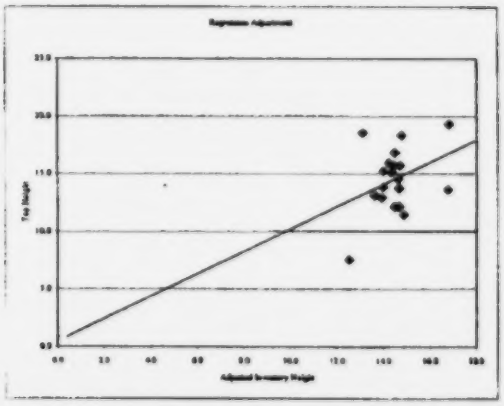


Figure 5.3 Regression adjustment of heights – PFT #2

Using the regression adjusted heights, VDYP is used to re-estimate volumes. The improvement in volume estimates is demonstrated in the Table 5.4 and Figures 5.4 and 5.5. There is no significant remaining difference to justify further volume adjustments.

Table 5.4 Adjustment comparison - PFT #2

	Adjusted Inventory	Field Based	Ratio	Correlation	T-test
Total height (m)	14.48	14.48	-	-	
Net Volume (m^3/ha)	86.40	82.74	0.9576	0.0387	-1.06

Note: t-statistic = 2.101 (an absolute value greater than the t-statistic indicates a significant difference).

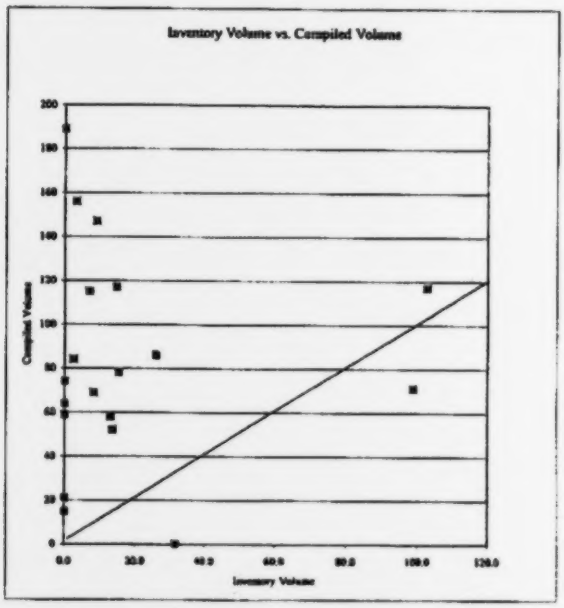


Figure 5.4 Volume comparison – PFT #2

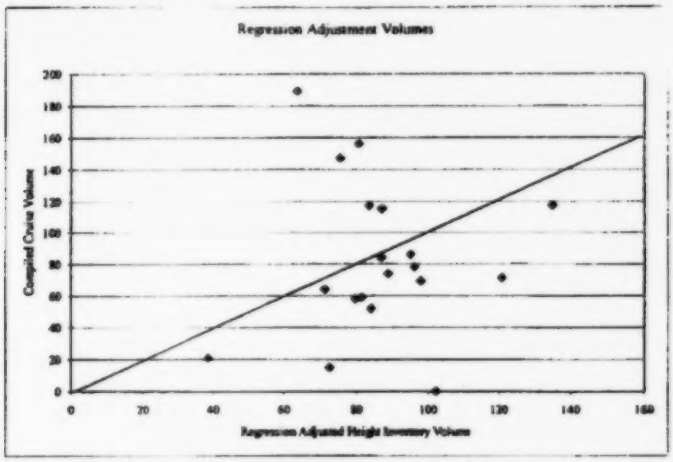


Figure 5.5 Volume after height adjustment – PFT #2

5.2 PFT #5 Results

Eighteen samples contributed to the analysis of PFT #5. Tables 5.5 and 5.6 provide data and comparison summaries.

Table 5.5 Data summary PFT #5

	Inventory Data			Top Height Plot Data		Net Volume (m^3/ha)	
	Age (years)	Height (m)	VDYP Net Volume (m^3/ha)	Age (years)	Height (m)	Compiled Cruise	VDYP Ground Attribute
Mean	55.56	15.68	74.28	59.14	16.86	97.89	94.54
Standard deviation	5.24	2.11	30.60	16.83	2.25	62.00	52.25
Sampling error %	4.7%	6.7%	20.5%	14.2%	6.6%	31.5%	27.5%
Upper confidence interval	58.17	16.73	89.50	67.51	17.98	128.72	120.52
Lower confidence interval	52.95	14.63	59.06	50.77	15.74	67.06	68.56

Note: 95% significance level.

Table 5.6 Inventory comparison summary PFT #5

	Inventory	Field Based	Ratio	Correlation	T-test
Total age (years)	55.56	59.14	1.0645	0.0765	1.777
Total height (m)	15.68	16.86	1.0751	-0.0037	1.3798
Net volume (m^3/ha)	74.28	97.89	1.3179	0.6262	6.9455

Note: t-statistic 2.110 (an absolute value greater than the t-statistic indicates a significant difference).

The data demonstrates no significant difference in age or height estimates between the inventory and field measured values. Differences in volume between VDYP inventory predictions and compiled cruise data are about 30% and demonstrated to be significant.

No changes to attributes are warranted based on the data. However, volume estimates are inadequate and some adjustment is required.

Figure 5.6 displays the VDYP predicted inventory volume against the compiled cruise volume.

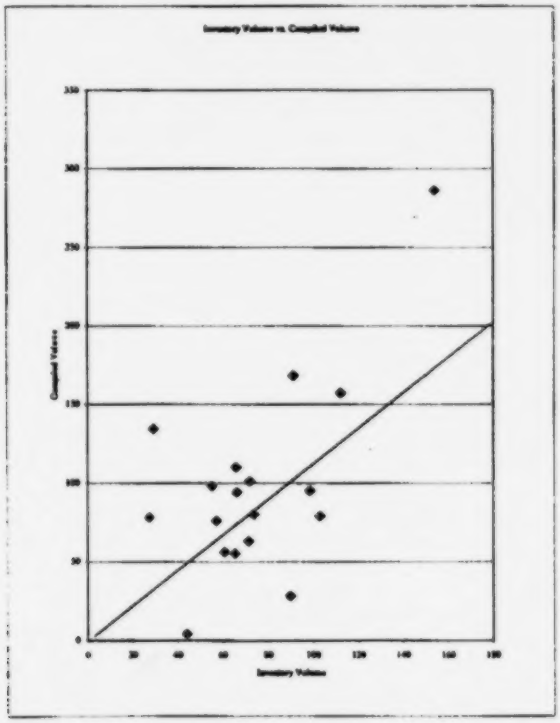


Figure 5.6 Inventory vs. cruise volume - PFT #5

5.3 PFT #6 Results

Twenty samples contributed to the analysis of PFT #6. Tables 5.7 and 5.8 provide data and comparison summaries.

Table 5.7 Data summary PFT #6

	Inventory Data			Top Height Plot Data		Net Volume (m^3/ha)	
	Age (years)	Height (m)	VDYP Net Volume (m^3/ha)	Age (years)	Height (m)	Compiled Cruise	VDYP Ground Attribute
Mean	73.55	17.67	96.16	65.15	17.04	103.70	100.24
Standard deviation	6.31	2.05	27.27	12.36	2.86	40.88	37.25
Sampling error %	4.0%	5.4%	13.3%	8.9%	7.9%	18.5%	17.4%
Upper confidence interval	76.50	18.63	108.92	70.93	18.38	122.83	117.67
Lower confidence interval	70.60	16.70	83.40	59.37	15.70	84.57	82.80

Note: 95% significance level.

Table 5.8 Inventory comparison summary PFT #6

	Inventory	Field Based	Ratio	Correlation	T-test
Total age (years)	73.55	65.15	0.8858	0.3942	-5.2498
Total height (m)	17.67	17.04	.9646	0.2011	-0.7427
Net volume (m^3/ha)	96.16	103.70	1.0784	0.2338	2.4172

Note: t-statistic 2.093 (an absolute value greater than the t-statistic indicates a significant difference).

The data demonstrates no significant difference in height estimates between the inventory and field values. The age data demonstrates a significant difference and a moderate linear relationship (correlation co-efficient = 1.39). The difference in volume between VDYP inventory predictions and compiled cruise data of about eight percent is demonstrated to be significant.

Volume prediction is shown to be inadequate. To address this an adjustment to inventory ages is indicated.

Table 5.9 provides descriptive statistics for adjusted heights based on ratio of means, difference-of-means, and linear regression methodologies. One can see that the means of the adjusted values are equal (and match the mean of the field value). The regression estimate results in the smallest confidence error and tightest confidence interval.

Table 5.9 PFT #6 Age adjustment results

	Ratio Adjustment (*.8858)	Difference in Means (-8.4 m)	Linear Regression (*.772+8.3709)
Mean age	65.15	65.15	64.65
Standard deviation	5.59	6.31	5.06
Sampling error %	4.0%	4.5%	3.7%
Upper confidence interval	67.77	68.10	67.02
Lower confidence interval	62.53	62.20	62.28

The regression adjustment to age results in a stronger relationship between ground based age and inventory age. Using the regression adjusted ages, VDYP is used to re-estimate volumes. The improvement in volume estimates is demonstrated in Table 5.10 and Figures 5.7 and 5.8.

Table 5.10 Comparison summary PFT #6

	Adjusted Inventory	Field Based	Ratio	Correlation	T-test
Total age (years)	64.65	65.15	-	-	-
Total height (m)	17.67	17.04	-	-	-
Net Volume (m^3/ha)	95.57	103.70	1.0851	0.3247	2.728

Note: t-statistic = 2.093 (an absolute value greater than the t-statistic indicates a significant difference).

Downward adjustment of age as indicated by the data results in an increase in site index and as a result higher predicted volumes at a given age. With the actual age reduction comes a volume reduction and no apparent increase in predicted volumes. The data indicates the lower age and the higher volume so the further volume adjustment is valid.

There is a significant remaining difference to justify further volume adjustments.

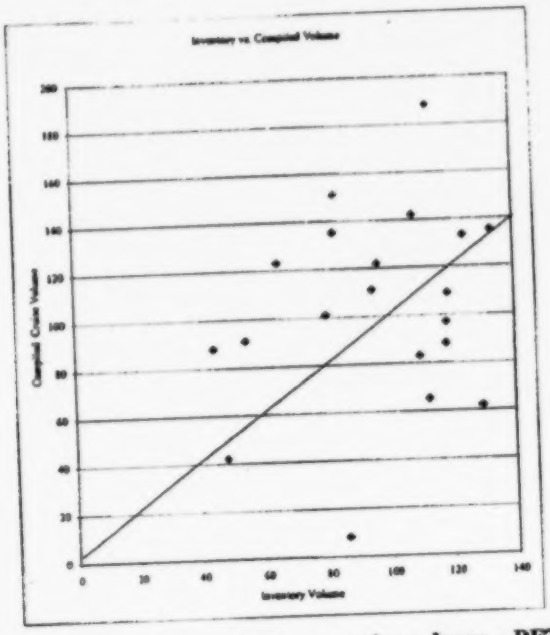


Figure 5.7 Inventory volume vs. cruise volume – PFT #6

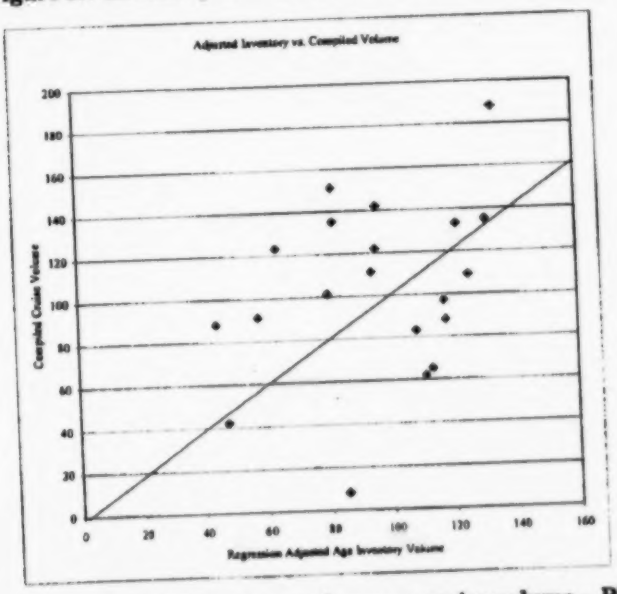


Figure 5.8 Adjusted Inventory volume vs. cruise volume – PFT #6

5.4 PFT #7 Results

Twenty-three samples contributed to the analysis of PFT # 7. Tables 5.11 and 5.12 provide data and comparison summaries.

Table 5.11 Data summary PFT #7

	Inventory Data			Top Height Plot Data		Net Volume (m^3/ha)	
	Age (years)	Height (m)	VDYP Net Volume (m^3/ha)	Age (years)	Height (m)	Compiled Cruise	VDYP Ground Attribute
Mean	96.61	17.48	99.16	82.17	16.73	82.83	93.17
Standard deviation	11.68	2.21	31.05	14.02	3.07	39.94	36.82
Sampling error %	5.2%	5.5%	13.5%	7.4%	7.9%	20.9%	17.1%
Upper confidence interval	101.66	18.44	112.58	88.24	18.06	100.10	109.0
Lower confidence interval	91.56	16.53	85.73	76.11	15.40	65.55	77.25

Note: 95% significance level.

Table 5.12 Inventory comparison summary PFT #7

	Inventory	Field Based	Ratio	Correlation	T-test
Total age (years)	96.61	82.17	0.8506	-0.2484	-7.0053
Total height (m)	17.48	16.73	0.9570	0.3296	-09295
Net volume (m^3/ha)	99.16	82.83	0.8353	0.4920	-5.9118

Note: t-statistic 2.074 (an absolute value greater than the t-statistic indicates a significant difference).

The data demonstrates no significant difference in height estimates between the inventory and field values. Age demonstrates significant difference, but exhibits a weak linear relationship. The statistically significant difference in volume between VDYP inventory predictions and compiled cruise data is about 17%.

Although the comparison data is not shown above, ground attribute volume demonstrates a significant difference from compiled volumes with quite strong linearity. This indicates residual error due to site index or VDYP modeling, and that adjustments can not be expected to fully remove the bias.

Table 5.13 provides descriptive statistics for adjusted ages based on ratio of means and difference of means methodologies. Due to the low linearity of the age data no regression analysis was undertaken. One can see that the means of the adjusted values are equal (and match the mean of the field value).

Table 5.13 PFT #7 adjustment results

	Ratio Adjustment (*.8506)	Difference in Means (-14.44m)
Mean age	82.18	82.21
Standard deviation	9.94	11.68
Sampling error %	5.2%	6.1%
Upper confidence interval	86.47	87.26
Lower confidence interval	77.88	77.16

The ratio adjustment results in a stronger relationship between ground based top height age and inventory age.

Using the ratio adjusted ages, VDYP is used to re-estimate volumes. The change in volume estimates is demonstrated in the Table 5.14 and Figures 5.9 and 5.10. There is a significant remaining difference to justify a volume reduction.

Table 5.14 Comparison summary PFT #7

	Adjusted Inventory	Field Based	Ratio	Correlation	T-test
Total age (years)	82.18	82.17	-	-	-
Total height (m)	17.48	16.73	-	-	-
Net Volume (m^3/ha)	97.54	82.83	0.8353	0.4920	-5.9119

Note: t-statistic = 2.074 (an absolute value greater than the t-statistic indicates a significant difference).

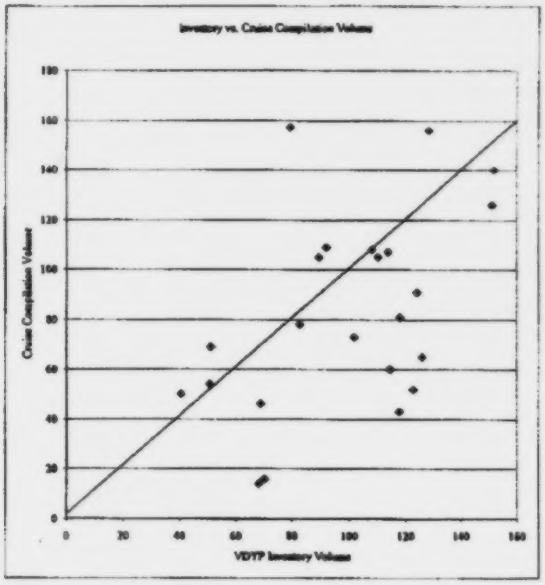


Figure 5.9 Inventory Volume vs. Cruise Volume – PFT#7

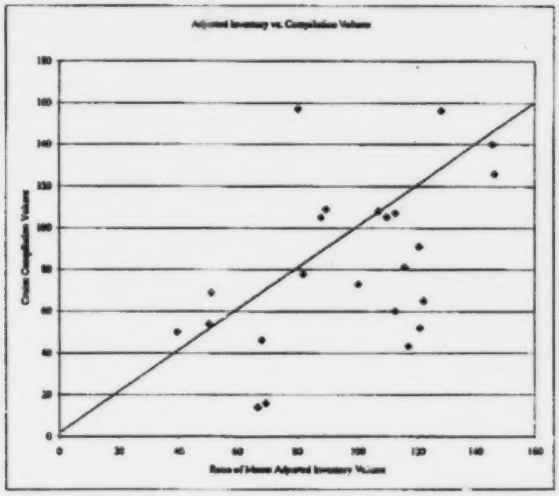


Figure 5.10 Adjusted Inventory Volume vs. Cruise Volume - PFT #7

5.5 PFT #12 Results

Twenty samples contributed to the analysis of PFT #12. Tables 5.15 and 5.16 provide data and comparison summaries.

Table 5.15 Data summary PFT #12

	Inventory Data			Top Height Plot Data		Net Volume (m^3/ha)	
	Age (years)	Height (m)	VDYP Net Volume (m^3/ha)	Age (years)	Height (m)	Compiled Cruise	VDYP Ground Attribute
Mean	57.60	16.23	115.19	59.10	17.19	154.65	149.06
Standard deviation	4.79	2.14	35.23	8.32	2.67	83.12	31.93
Sampling error %	3.9%	6.2%	14.3%	6.6%	7.3%	25.2%	10.0%
Upper confidence interval	59.84	17.23	131.68	62.99	18.43	193.55	164.00
Lower confidence interval	55.36	15.22	98.69	55.21	15.94	115.75	134.12

Note: 95% significance level.

Table 5.16 Inventory comparison summary PFT #12

	Inventory	Field Based	Ratio	Correlation	T-test
Total age (years)	57.60	59.10	1.0260	-0.0095	1.0215
Total height (m)	16.23	17.19	1.0592	0.5408	1.3237
Net Volume (m^3/ha)	115.19	154.65	1.3426	0.3172	9.3704
Ground Attribute Volume (m^3/ha)	149.06	154.65	1.0375	0.6480	1.444

Note: t-statistic 2.093 (an absolute value greater than the t-statistic indicates a significant difference).

The data demonstrates no significant difference in age or height estimates between the inventory and field values, although height demonstrates a moderate to strong linear relationship. Differences in volume between VDYP inventory predictions and compiled cruise data are large and significant.

Although not quite significantly different, volumes calculated with VDYP based on ground attributes demonstrate a difference from compiled volumes with strong linearity. This indicates some residual error due to site index or VDYP modeling, but most bias is to be explained by inventory attributes. With a six per cent difference and a t-test value of 1.3 there is some basis for adjusting heights. This has not been done here and it must suffice that the difference in heights and other attributes would support an adjustment to volume.

5.6 PFT #13 Results

Eighteen samples contributed to the analysis of PFT # 13. Tables 5.17 and 5.18 provide data and comparison summaries.

Table 5.17 Data summary PFT #13

	Inventory Data			Top Height Plot Data		Net Volume (m^3/ha)	
	Age (years)	Height (m)	VDYP Net Volume (m^3/ha)	Age (years)	Height (m)	Compiled Cruise	VDYP Ground Attribute
Mean	70.17	16.68	125.69	63.89	18.23	142.61	147.5
Standard deviation	5.33	2.39	35.25	10.75	2.97	65.67	34.19
Sampling error %	3.8%	7.1%	13.9%	8.45	8.1%	22.9%	11.5%
Upper confidence interval	72.82	17.87	143.22	69.24	19.70	175.27	164.5
Lower confidence interval	67.52	15.49	108.17	58.54	16.75	109.95	130.50

Note: 95% significance level.

Table 5.18 Inventory comparison summary PFT #13

	Inventory	Field Based	Ratio	Correlation	T-test
Total age (years)	70.17	63.89	0.9105	0.5661	-4.3352
Total height (m)	16.68	18.23	1.0926	0.3029	1.7789
Net volume (m^3/ha)	125.69	142.61	1.1346	-0.0544	3.9916

Note: t-statistic 2.110 (an absolute value greater than the t-statistic indicates a significant difference).

The data demonstrates no significant difference in height estimates between the inventory and field values. Age demonstrates significant difference and strong linearity. Site index, although not shown on the tables above (please see Appendix III), also demonstrates a significant difference and some linear relationship. Differences in volume between VDYP inventory predictions and compiled cruise data are about 13% and significant.

Volume prediction using VDYP is shown to be biased. Recommended is an adjustment to inventory ages.

Table 5.19 provides descriptive statistics for adjusted heights based on ratio of means, difference of means, and linear regression methodologies. One can see that the means of the adjusted values are equal (and match the mean of the field value). The ratio adjustment estimate results in the smallest confidence error and tightest confidence interval.

Table 5.19 PFT #13 adjustment results

	Ratio Adjustment (*0.9105)	Difference in Means (-6.28m)	Linear Regression (*1.1427-16.288)
Mean age	63.89	63.89	63.18
Standard deviation	4.58	5.33	5.99
Sampling error %	3.8%	4.1%	4.7%
Upper confidence interval	66.30	66.54	66.15
Lower confidence interval	61.47	61.24	60.19

The ratio of means methods appears to provide the best result. Inventory age, before and after adjustment is demonstrated by Figures 5.11 and 5.12.

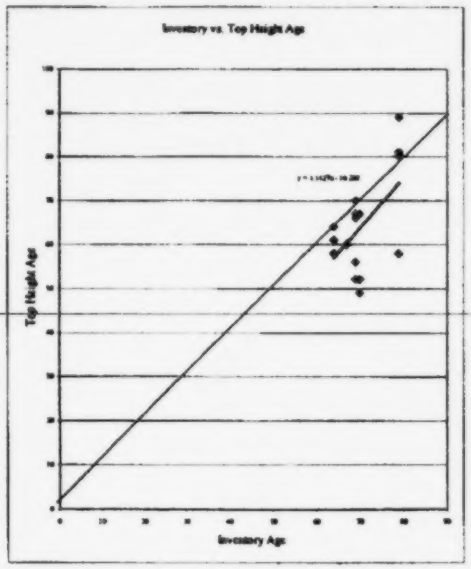


Figure 5.11 Inventory Age vs. Top Height Age – PFT #13

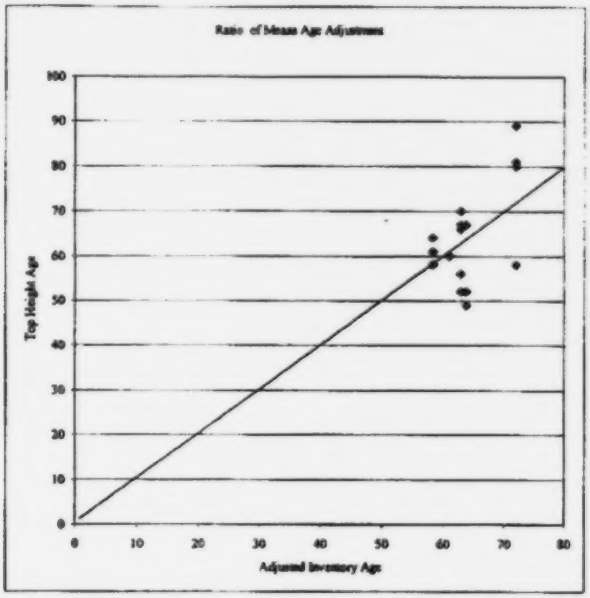


Figure 5.12 Adjusted Inventory Age vs. Top Height Age – PFT #13

Using the ratio adjusted heights, VDYP is used to re-estimate volumes.

Although heights are shown to be not significantly different, 1.77 is marginal in terms of a t-statistic of 2.110. It is difficult to ignore a difference of 9% given that the data indicates the relationship to be fairly linear (the correlation co-efficient is 0.3). Another VDYP re-calculation was performed based on regression-adjusted heights as well as ratio adjusted ages.

The results of these recalculations of volume are presented in Table 5.20 and Figures 5.13 and 5.14.

Table 5.20 Comparison summary PFT #13

	Adjusted Inventory	Field Based	Ratio	Correlation	T-test
Total age (years)	63.89	63.89	-	-	-
Total height (m)	16.68	18.23	-	-	-
Ratio age adjusted net volume (m^3/ha)	123.87	142.61	1.1346	-0.0544	3.9916
Age and height adj. net volume (m^3/ha)	143.62	142.61	0.9930	-0.1808	-0.2388

Note: t-statistic = 2.110 (an absolute value greater than the t-statistic indicates a significant difference).

In the case of the age-only adjusted attribute volumes, there is a significant remaining difference to justify further volume adjustments. There is no remaining bias in the case of the age and height adjusted volumes.

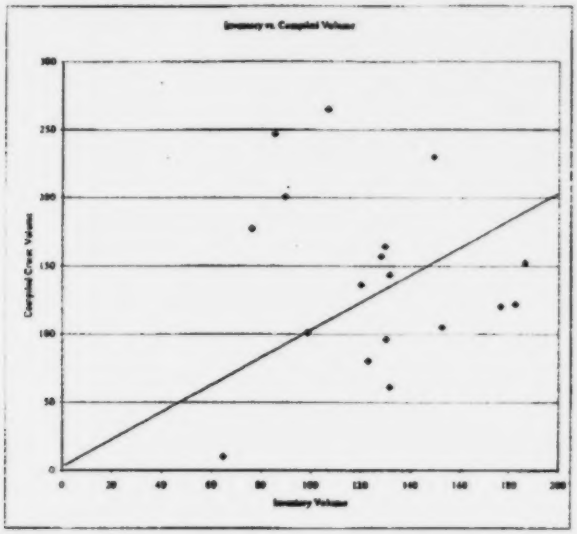


Figure 5.13 Inventory vs. Cruise Compiled Volume – PFT #13

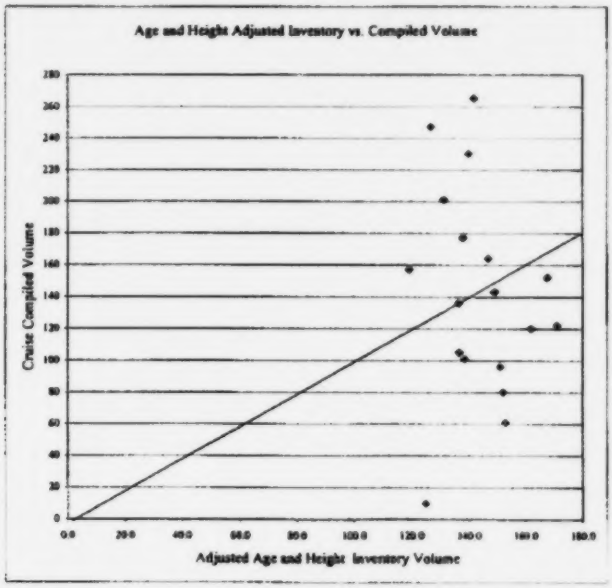

Age and Height Adjusted Inventory vs. Compiled Volume
Cruise Compiled Volume
Adjusted Age and Height Inventory Volume

Figure 5.14 Adjusted Inventory vs. Cruise Compiled Volume – PFT #13

5.7 PFT #14 Results

Nineteen samples contributed to the analysis of PFT # 14. Tables 5.21 and 5.22 provide data and comparison summaries.

Table 5.21 Data summary PFT #14

	Inventory Data			Top Height Plot Data		Net Volume (m^3/ha)	
	Age (years)	Height (m)	VDYP Net Volume (m^3/ha)	Age (years)	Height (m)	Compiled Cruise	VDYP Ground Attribute
Mean	106.74	16.30	109.57	96.00	16.60	168.42	97.97
Standard deviation	15.41	2.02	44.33	17.22	3.36	85.33	32.34
Sampling error %	7.0%	6.0%	19.5%	8.6%	9.8%	24.4%	15.9%
Upper confidence interval	114.17	17.27	130.93	104.30	18.22	209.55	113.56
Lower confidence interval	99.31	15.33	88.20	87.70	14.96	127.29	82.38

Note: 95% significance level.

Table 5.22 Inventory comparison summary PFT #14

	Inventory	Field Based	Ratio	Correlation	T-test
Total age (years)	106.74	96.00	0.8994	0.3766	-5.2428
Total height (m)	16.30	16.60	1.0184	0.3314	0.3448
Net volume (m^3/ha)	109.57	168.42	1.5371	-0.0538	12.3963

Note: t-statistic 2.110 (an absolute value greater than the t-statistic indicates a significant difference).

The data demonstrates no significant difference in height estimates between the inventory and field values. Age demonstrates significant difference and strong linearity. Differences in volume between VDYP inventory predictions and compiled cruise data are very large and clearly significant.

Table 5.23 provides descriptive statistics for adjusted ages based on ratio of means, difference-of-means, and linear regression methodologies. One can see that the means of the adjusted values are equal (and match the mean of the field value). The regression adjustment estimate results in the smallest confidence error and tightest confidence interval.

Table 5.23 PFT #14 adjustment results

	Ratio Adjustment (*0.8994)	Difference in Means (-10.74)	Linear Regression (* 4208+51.09)
Mean age	96.00	96.00	95.58
Standard deviation	13.86	15.41	6.55
Sampling error %	7.0%	7.7%	3.3%
Upper confidence interval	102.68	103.43	98.74
Lower confidence interval	89.32	88.57	92.42

In this case, linear regression provides the most improvement in our age estimates. The adjustments are presented graphically in Figures 5.15 and 5.16.

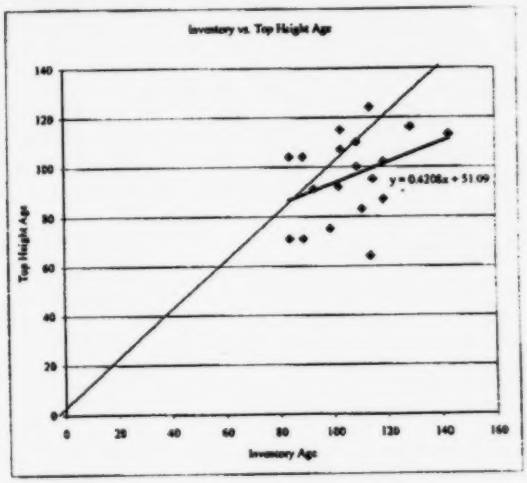


Figure 5.15 Inventory Age vs. Top Height Age – PFT #14

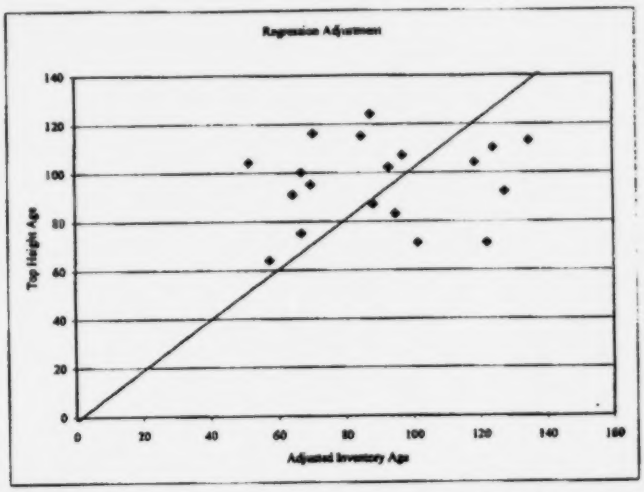


Figure 5.16 Adjusted Inventory Age vs. Top Height Age – PFT #14

Volume prediction using VDYP is shown to be biased. In the case of PFT #14 this is complicated by the criterion that all polygons be stocking class 4. Stocking class 4 is defined as mature lodgepole pine not disturbed more than 25%, having less than 76 trees per hectare that are 27.5cm dbh or greater, and having zero to 311 stems per hectare greater than 17.5cm dbh (or if over 311, less than 50% of the stems 7.5cm or greater are 12.5cm or greater). VDYP reduces volumes of stocking class 4 stands by 50%. This is an imprecise approach to using stocking as a variable for volume prediction.

The actual stocking class values, based on cruise stand and stock tables, are provided for PFT #14 in Appendix III. It is interesting to note that only seven of the nineteen samples remain stocking class 4.

Ratio adjusted age and recalculated stocking class are used to re-estimate volumes using VDYP. VDYP is also used to re-estimate volumes using the regression adjusted ages. The improvements in volume estimates are demonstrated in Table 5.24 and Figures 5.17 and 5.18.

Adjustments to age and stocking result in the better estimates of volume but there remains a significant difference requiring further volume adjustments. Stocking class is a discreet variable and therefore not adjustable, as in the case of age and height. For these reasons, the regression adjusted ages are recommended, followed by a further volume adjustment.

Table 5.24 Comparison summary PFT #14

	Adjusted Inventory	Field Based	Ratio	Correlation	T-test
Total age (years)	95.58	96.00	0.8994	0.3766	-5.2428
Total height (m)	16.30	16.60	1.0184	0.3314	0.3448
Age and stocking class adjusted net volume (m^3/ha)	125.31	168.42	1.3440	0.4267	10.1775
Regression adjusted Net volume (m^3/ha)	90.61	168.42	1.8588	0.1559	17.6004

Note: t-statistic = 2.101 (an absolute value greater than the t-statistic indicates a significant difference).

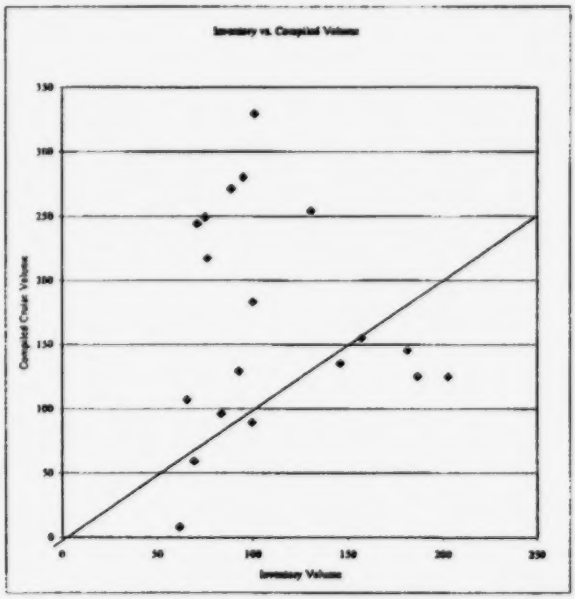


Figure 5.17 Inventory vs. Cruise Compiled Volume – PFT #14

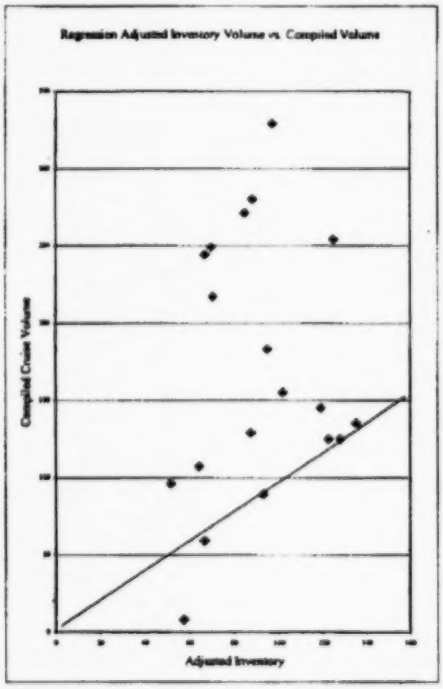


Figure 5.18 Adjusted Inventory vs. Cruise Compiled Volume – PFT #14

6. ANALYSIS RESULTS

This section presents the analysis results associated with our recommended strategies for inventory adjustment.

Based on the field data, heights generally, other than PFT #2, appear to be portrayed accurately in the inventory and it is ages that require adjustment.

PFT #2 consists of very short lodgepole pine over a wide range of ages. The ages are generally accurately portrayed in the inventory but heights are not. The field data is used to increase accuracy of height estimates—generally increase the height. The result is to redistribute PFT #2 (height class 1) amongst the PFT #'s 12, 13, and 14 which are height class 2 and age class 3, 4, and greater than 4 respectively.

Pine and Douglas-fir stands 41 to 60 years of age and height class 2 (PFT #s 5 and 12) indicate no statistically significant bias in age or height. In both cases the exhibited difference in height (a positive factor) is offset by the difference in age (a negative factor). In both cases there is a significant bias indicated in VDYP volume prediction. The bias largely, but not entirely, disappears when VDYP is used with ground attribute inputs.

Data collected in PFT #6 (Douglas-fir 61-80 years, height class 2) indicates an adjustment of ages is required. VDYP volumes using adjusted ages still exhibit a significant difference from compiled cruise volumes. VDYP volumes based on ground based attributes are not significantly different from cruise data. PFT #7 (Douglas-fir greater than 80 years, height class 2) is similar, with the exception that ground based VDYP is significantly biased and therefore presents a stronger case for volume adjustments.

For PFT #13 ages are adjusted and the resulting volume values indicate residual bias. Heights were not adjusted, but they are marginally significant and there is some basis for adjusting these as well. This is supported by the fact that the ground attribute VDYP values are not significantly different from the compiled cruise values, from which one concludes no bias associated with modeling. Analysis was undertaken using adjusted ages with and without adjusted heights.

PFT #14 is lodgepole pine over 80 years of age, height class 2 and stocking class 4. The data calls for an age adjustment. After such an adjustment volumes are still grossly underestimated by VDYP, as they are with ground attributes. One source of error is the stocking class 4 attribute. Adjustment of this attribute based on ground data improves the problem but does not solve it. Stocking class, being a discrete class variable can not be manipulated as is possible with age or height and application of such an adjustment to unsampled stands is not possible. The only recourse is a substantial adjustment to volumes.

Table 6.1 provides a summary of key data and recommended adjustments.

Table 6.1 Adjustments summary

PFT Type	Proposed Sample Number	Actual Sample Number	Attribute Adjustments	Residual Volume Multiplier
2	25	19	ht. = ht*.354+11.199	none
5	20	18	none	1.3179
6	22	20	age = age*.772+8.3709	1.0851
7	25	23	age = age*.8506	0.8353
12	22	20	none	1.3426
13	20	18	age = age*0.9105	1.1346
14	20	19	age = age*.4208+51.09	1.8588

6.1 Timber Supply Implications

Table 6.2 provides a summary of area and volume by PFT before and after attribute adjustments are made. The area reported is operable crown land in the Cranbrook TSA. No further reductions for TSR 1 land base net downs were performed. Volumes are summed polygon net merchantable volume at 12.5 cm dbh utilization as predicted by VDYP based on stands projected to 1997.

Table 6.2 PFT area and volume summary

	Unadjusted		Adjusted Attributes		Adjusted Attributes and Volumes	
PFT Type	Operable Area (ha)	Volume (m3)	Operable Area (ha)	Volume (m3)	Operable Area (ha)	Volume (m3)
2	2,676	27,131	11	63	11	63
5	7,288	503,677	10,013	730,321	10,013	908,709
6	13,923	1,129,348	15,675	1,297,690	15,675	1,309,582
7	14,354	1,315,012	9,877	890,366	9,877	743,722
12	31,691	3,411,661	50,223	5,962,076	50,223	7,462,955
13	46,203	5,801,688	30452	4,291,466	30452	4,873,645
14	13,411	2,034,136	13,451	1,948,793	13,451	3,620,524
Total	**129,546**	**14,222,653**	**129,546**	**15,120,775**	**129,546**	**18,919,200**

With the adjustments as made, no areas move out of the PFT category. However, there is significant movement between categories, which has an impact in the context of various partial net downs, see Tables 6.3 and 6.4.

Table 6.3 PFT category shift

PFT Indicated by Inventory	PFT after Adjustments	Area (ha)
2	2	11
2	12	2,058
2	13	567
2	14	40
5	5	7,288
6	5	2,725
6	6	11,198
7	6	4,477
7	7	9,877
12	12	31,691
13	12	16,474
13	13	29,729
14	14	13,411
		Total 129,546

Table 6.4 PFT contribution to net harvesting land base

		Total Operable Area	PFT Contribution under TSR I		PFT Contribution after Attribute Adjustments		PFT Attribute and Volume Adjustments	
PFT Type	TSR I % Net Down	area (ha)	area (ha)	volume (m3)	area (ha)	volume (m3)	area (ha)	volume (m3)
2	80	2,676	535	5,426	2	13	2	13
5	10	7,288	6,559	453,309	9,012	657,289	9,012	817,838
6	20	13,923	11,138	903,478	12,540	1,038,152	12,540	1,047,666
7	40	14,354	8,612	789,007	5,926	534,220	5,926	446,233
12	15	31,691	26,937	2,899,912	42,690	5,067,765	42,690	6,343,512
13	25	46,203	34,652	4,351,266	22,839	3,218,600	22,839	3,655,234
14	50	13,411	6,706	1,017,068	6,726	974,397	6,726	1,810,262
Total		**129,546**	**95,140**	**10,419,467**	**99,734**	**11,490,434**	**99,734**	**14,120,757**

The adjustment strategy increases the net land base by 4,594 ha (4.8%) and indicates that there are 3.7 million metres of volume available than previously believed (an increase of 35% on PFTs).

7. ALTERNATE NET DOWN STRATEGY

Section 6 of this report provides results of an inventory attribute and volume adjustment strategy based on extensive field sampling. Impacts are presented in terms of a net down strategy as defined in Timber Supply Review (TSR) I. Sampling strata were based on TSR I PFT definitions. Adjustments to inventory attributes moved stands from one PFT to another resulting in smaller area reductions based on partial net down assumptions made in TSR I.

Historically, land base reductions for PFTs have been in the form of partial net downs and net down percentages were based on anecdotal evidence only. This project provides considerable data upon which to improve the net down strategy.

In the context of multiple resource constraints and an ever-tightening timber supply situation, spatial timber supply analysis is increasing in importance. Partial net downs are a hindrance to this process. Age and height are the main drivers in PFT classification. In the process of this project we have provided the tools to significantly improve these attributes in the inventory database. Marginal site index values could be used in place of age class and height class limits in the PFT definitions. With this change, all net downs could be total removals.

8. ALTERNATE STAND TREATMENT STRATEGY

The Cranbrook TSA Steering Committee is assessing the forest management strategy options that would optimize use of the Douglas-fir and pine leading PFT wood fibre. Treatments may be rehabilitation, commercial thinning or conventional harvest.

The committee is undertaking a classification exercise in which available data for each PFT sample is assessed for current or future merchantability. Once this is complete, an assumption as to the distribution of the area between treatments will be made for each PFT type. This will also provide appropriate net down factors that could be used for Timber Supply Review II.

This project has provided support for this exercise in various ways described below.

8.1 Compiled Stand and Stock Tables

Stand and stock tables were compiled for each sample. These tables provided stem and volume distribution information upon which to base assumptions related to current merchantability. Accompanying this was in plot slope data that is a factor in determining economic merchantability.

In addition, stand and stock tables were compiled for each PFT as a whole. These provide additional data for consideration of the current status of each PFT. Tabular and graphic data summaries can be found in Appendix IV.

8.2 Field Collected Stand Attributes

Field based stand attributes were provided to the MoF for use in predicting future merchantability. The MoF, using the volume prediction tools VDYP and Table Interpolation Program for Stand Yields (WinTIPSY), provided yield curves for assessing future merchantability.

8.3 PrognosisBC Data

To augment VDYP and WinTIPSY projections, PrognosisBC modeling was undertaken. This will be most useful in evaluating for silvicultural intervention such as commercial thinning. PrognosisBC is of particular value to this project given that VDYP is insensitive to stocking given the use of a non-dynamic crown closure figure.

PrognosisBC is a stand growth model being adapted to use in B.C. by the Ministry of Forests. It is well suited to ground inventory data such as that available through this project. In-order to facilitate projection of stands from current conditions, the field data gathered for this project included custom data items to take advantage of Prognosis BC self-calibration functionality.

Field data processed by PrognosisBC includes a complete stand table, crown descriptions for all trees, diameter increments for trees measured for age, height increments for trees under 7.5cm dbh, biogeoclimatic classification, elevation, aspect, and latitude.

PrognosisBC modeling of select samples as chosen by the Steering Committee has been undertaken and is reported under separate cover.

APPENDIX I - SAMPLING PLAN

SAMPLING PLAN FOR CRANBROOK FIR AND PINE PFT STUDY

June 27, 1997

by
Sam Otukol

Resources Inventory Branch

Timberline

INTRODUCTION

The Cranbrook Timber Supply Area (TSA) has approximately 124 687 hectares of forest land which are affected in the net-down process in which Douglas fir and small diameter yellow and lodgepole pine are involved. In the net-down process, portions of, or entire forest stands are excluded from the harvest land base during the determination of the Allowable Annual Cut (AAC). Historically, the basis for determining the percentage of net down on a given polygon was derived from anecdotal information, and there was no empirical data to support the "problem forest type" related net-down.

The forecast for the short-term timber supply prospects for the Cranbrook TSA are not optimistic (TSR Discussion Paper, March 1995). The following factors will negatively impact on the short-term timber supply:

- increased forest cover requirements for integrated resource management;
- increased requirements to maintain older forests; and
- increased minimum harvest ages.

In the 1995 discussion paper, four factors were identified as having the potential to increase or decrease the sort-term timber supply. These are:

1. improved estimates of unsalvageable timber losses;
2. improved estimates of existing mature timber volumes;
3. a change in the size of the timber harvesting land base; and
4. changes in green-up requirements.

This survey of pine and fir problem forest types (PFTs) has the potential of making an impact in relation to factors 2 and 3.

This sampling plan outlines a process for acquiring empirical field data to quantify the volume and area coverage the Pine leading Problem Forest Types (PFTs), and verify the accuracy of the associated net-down criteria in the Cranbrook TSA.

OBJECTIVES

As a follow-up to TSR discussion paper statements, the objectives of this study will be as follows:

1) To determine the site productivity potential for the stratum of interest by sampling to estimate site index;

2) To evaluate the merchantability of the timber products for the stratum of interest;

3) to determine the "piece size" distribution and quantify the proportion of saw-log and small wood components of the inventory;

4) To develop a management strategy regarding the Douglas-fir and pine component of the stratum by establishing the following:

a) relationship between site series and site index,

b) thinning/rehabilitation potential.

In addition to the objectives stated above, the Cranbrook TSA would like to address the following, specific issues:

1) Obtain reliable diameter distributions to allow an evaluation of product potential;

2)Collect data on growth rates, i.e., rate of basal area increase, and evaluate tree crown characteristics;.

3) Update the Douglas-fir and pine problem forest type inventory through adjustment;

4) Develop new criterion for netting down timber harvest land base, based on individual polygon characteristics; and

5) Explore the possibility of developing a more reliable methodology for determining site productivity.

DESCRIPTION OF THE STRATUM OF INTEREST

There are several categories of problem forest types in the Cranbrook TSA. The categories that are of interest in this particular study are presented in Table 1.

Table 1. Variation within different PFT categories.

PFT #	Area (ha)	Species/age/ht	ITG	Age Class	Height Class	Stock Class	Site Class	Cv %	% Exclusion
2	2744	Pl ht<10.5 age>41	28-31	>2	1	all	G,M,P,L	91.7	80
5	6870.0	F, Py 41-60yrs 10.5-19.4m	5-8 & 32	3	2	0, 2	M,P,L	44.6	10
6	15426.0	F, Py 61-80yrs 10.5-19.4m	5-8 & 32	4	2	0, 2	M,P,L	35.3	20
7	12066.0	F, Py >80yrs 10.5-19.4m	5-8 & 32	>4	2	0, 2	M,P,L	28.8	40
12	37553.9	Pl 41-60yrs 10.5-19.4m	28-31	3	2	0, 2	G,M,P,L	34.6	15
13	46929.1	Pl 61-80yrs 10.5-19.4	28-31	4	2	0, 2	G,M,P,L	25.9	25
14	3099.4	Pl >80yrs 10.5-19.4m	28-31	>4	2	0, 2, 4	G,M,P,L	26.6	50
Total	124688.4								

A different proportion of net-down is applied to each of the categories presented in Table 1. For the 7 categories of pine leading stands (PFT 2, 5, 6, 7, 12, 13 and 14) the proportions of net down are; 80%, 10%, 20%, 40%, 15%, 25% and 50%, respectively. Each of the 7 categories will be treated as a separate sub-population and an allowable sampling error of 15% will be the basis for determining the approximate sample size to be allocated to each sub-population.

SAMPLING DESIGN

The purpose of the study is to collect ground data from the Douglas-fir and pine leading PFT stratum and use it to adjust the existing inventory information, if any biases are encountered. The existing inventory attributes will be considered as estimates, while the ground values will be considered as measures of the "truth". If the ground measurements indicate the inventory attributes are biased, the ground data will be used to develop ratio or regression relationship to adjust the inventory attribute estimates.

Stratification

The district will be stratified by PFT category as indicated in Table 1. The intent is to obtain an answer for both the management unit as a whole, as well as for each PFT.

Sample Size Determination

For the 7 categories of PFT provided in Table 1, PFT 2 has the largest amount of variation. The CV for this category is 91.7%. All the other PFTs have CVs ranging from 25.9% to 44.6%. The diversity in site condition and species composition may be responsible for the high variability.

In terms of area representation, this PFT constitutes only 2.3% of the PFT land base. However, 80% of the land area in this PFT is excluded from the timber harvest land base. For this reason, relatively more samples need to be established in this PFT to establish its impact in the net-down process. Considering the cost limitations, this PFT was allocated a sample size of 25. Given the amount of variation in the type, this sample size will most likely produce a sampling error larger than 15%, but it will provide enough information to allow an independent adjustment of the type. The sample size allocations for the other PFTs are provided in Table 2.

Table 2. Sample sizes for different PFT categories.

PFT #	Area (ha)	Species	ITG	Age Class	Ht Class	Sample weights	Cv %	% Exclusion	Sample Size
2	2,744	Pl age>41 ht<10.5	28-31	>2	2	110	91.7	80	25
5	6,870	F, Py 41-60yrs 10.5-19.4m	1,5-8 & 32	3	2	344	44.6	10	20
6	15,426	F, Py 61-80yrs 10.5-19.4m	1,5-8 & 32	4	2	701	35.3	20	22
7	12,066	F, Py >80yrs 10.5-19.4m	1,5-8 & 32	>4	2	483	30.5	40	25
12	37,553	Pl 41-60yrs 10.5-19.4m	28-31	3	2	1707	34.6	15	22
13	46,929	Pl 61-80yrs 10.5-19.4m	28-31	4	2	2346	25.9	25	20
14	3,099	Pl >80yrs 10.5-19.4m	28-31	>4	2	155	26.6	50	20
Total	124,687					5846			154

Notes to Table 2: The sample sizes for each PFT were computed independently using the type CV, therefore the sample sizes are not proportional to type area representation. A weighting process will be required to give each sample equal weight during the computation of overall PFT attribute averages. The "sample weights" column in Table 2 provides the weights to be used for each type.

Sample Selection

The selection of polygons to be sampled should use the principles of probability selection. The target stratum (Douglas fir and pine leading PFT polygons) will be identified, and a complete list created to constitute the sampling frame for the target population. The information provided in Table 1, will be used to identify polygons that are eligible for inclusion in the target population.

Samples will be selected from that list by type. That way the bias associated with subjective choice of polygons will be eliminated, and the credibility of the collected data will be enhanced. The following selection procedure should be followed:

- A complete list of polygons belonging to the target population should be compiled. At this stage, only the unique polygon identification number, the map sheet on which the polygon is located, the PFT, the species composition, age height, landscape unit & site index, and the area of the polygon are required to make the sample selection.
- The polygons in each PFT should be sorted by "landscape unit", age, height (and/or site index). The reason for this sort criterion is that there is a desire to have a uniform spread of samples across the "landscape units", age, and height ranges for each PFT.
- Compute cumulative totals of the polygon areas, beginning with the first polygon in the list foe each PFT.
- Compute the sampling interval by dividing the total area of the PFTs by the desired sample size (e.g., 8203.4/12=684).
- Generate a random number between 1 and the interval (684) computed above. This number identifies the first polygon selection.
- Add the sampling interval to the random number generated and continue adding the interval successively until the last selection is made (see Table 2).
- The nth polygon in the list is selected if a generated number falls within the interval of cumulated area totals for the n-1 and nth polygons in the list. This procedure selects the polygons with probability proportional to the polygon area size (see Table 3 for illustration).

Table 3. An illustration of the selection of polygons with probability proportional to area of polygon.

Map sheet #	Poly #	Species Composition	Area (ha)	Acc Area (ha)
82N025	352	S100	21	21
82N052	38	S60B40	24	45***
82N055	819	H30B30F30S10	15	60
82M090	129	H90C10	12	72
82M072	243	C100	9	81
82N054	911	F50S30C10H10	4	85
82M080	74	S80B10H10	24	109
82N037	228	S50B30Pa20	55	164***
82N044	340	H100	12	176
82N009	533	Pl60Fd40	29	205
82N062	270	B60S40	20	225***
82N074	473	B60S40	45	270
82N067	214	S60B40	14	284***
82N091	117	S90B10	21	305
82N072	35	S60B40	73	378
82N052	132	S90B10	5	383
82N055	801	S40At40Pl20	26	409***
82N084	133	F60S40	4	413
83C002	87	H50C30F10S10	14	427
82N044	326	Pl40F30S20H10	23	450

Sampling specifications:

Sample size: 5
Sampling interval: 450/5 = 90
Random start #: 29 (should be any number between 1 and 90 - the sampling interval)
Selected polygons in list are indicated by "***".

Office preparation prior to field work.

After completing the selection of the polygons that will be sampled for adjustment, the following should be carried out in preparation for the field work:

1. Obtain a pair of stereo aerial photos covering the target polygon area
2. Determine accessibility of the target polygons, classifying them as either ground access or helicopter access polygons.

3. For the ground access polygons, identify tie points which will be used as reference for accessing the polygon.
4. For helicopter access polygons, identify potential landing locations.
5. Obtain 1:5,000 or 1:10,000 enlargement maps of the target polygons.
6. Transfer the tie point determined on the photos to the map.
7. Use audit sampling procedure for establishing a 9 point cluster within a polygon.
8. Identify full measure plots (four) and count plots (five) as described in the Inventory Audit Manual.
9. It is preferable to use fixed area plots in this study because better diameter distributions are obtained if fixed area plots are used as compared to variable radius plots.
10. Follow the inventory audit plot establishment and tree measurement procedures as described in the Inventory Audit Manual.

Tie Point Establishment and Navigation to Sample Plot

The procedure for establishing tie points and navigating to the first sample plot location is well described in the Inventory Audit Sampling procedures. Those procedures should be followed in establishing tie points and all other aspects of the field work.

Data Capture

The forms used for Inventory Audit sampling should be used during all field work.

DATA COMPILATION AND ANALYSIS

Upon completion of the data collection, the raw data will be submitted to a contractor for compilation. The Inventory audit group at the Resources Inventory Branch may be contacted regarding compilation if problems arise. If site series data compilation is required, special instructions may be required to obtain the desired information.

For the key attributes such as tree height, age, volume and site index, statistical tests will be performed to determine if there are differences between the map label values and the ground measured values. Tests, such as the t-test and the ratio test for differences between means will be performed. If these tests indicate a significant bias of the map label attributes, correlation analysis will be performed to determine the strengths of the relationships between the ground measured values and the map label attributes.

Depending on the strength of the correlation relationships, and the general appearance of the scatter plots of the ground values against the map label attributes, a method for adjusting the inventory attributes will be chosen. The options may include regression, ratio or other, simpler, adjustments.

Each attribute will be considered separately, but reconciliation may be necessary for the derived attributes.

The derivation of site index / site series relationships may require some exploration. It will be possible to make statements regarding general relationships between site index and site series based on the sample data, however, extrapolation of this information beyond the sample may be problematic in that the relationships may not be strong.

The Resources Inventory Branch will provide advice on the analysis and in preparing parts of the final report.

The following is a synopsis of the proposed data analysis process, including some specific suggestions on what analysis should be performed:

1. Perform tests for differences between means for height, age, volume and site index.
2. Perform correlation analysis to determine the strength of the relationships between the ground measurement and map label estimates for height, age, volume, and site index.
3. Evaluate rate of miss-classification, i.e., do all the polygons in the sample confirm a dense pine or fir classification?
4. Perform the detailed analysis. Evaluate the following:

    a) Develop ratio or regression relationships to be used in adjusting the inventory attributes.

    b) Analyze the diameter and piece size distributions based on the sample. Assess the utilization requirements for the PFT timber.

    c) Analyze site index/site series relationships and determine the feasibility of improving site index estimation using these relationships.

    d) Assess the forest management strategy options that would optimize the production and exploitation of the Douglas-fir and pine leading PFT wood fibre.

Adjustment of Inventory Files

After the data analysis a process for adjusting the inventory files will be established. The participation of the Timber Supply personnel is required to ensure the acceptability of the new data for Timber Supply Review.

APPENDIX II – FIELD METHODOLOGY

Three sub-contractors, under direction of a Timberline on-site project manager, undertook the fieldwork. The on-site manager was responsible for field contractor liaison and quality control. The manager accompanied field contractors in the field for an initial training day to ensure appropriate and consistent methodology was used.

Methods were based on MoF Valuation Branch Cruising Standards. Plot structure and data collection procedures were as per the Resources Inventory Branch Inventory Audit Sampling Standards and Procedures (January 17, 1997) except as noted in this Appendix. Custom tally cards were used to aid in complete collection of non-standard items and to ensure consistent format across subcontractors.

Each sample is uniquely identified with a sample number that was recorded in the 'type' field in all card headers. This number, along with mapsheet and polygon, will identify all materials belonging to each sample and will be the basis of grouping for the polygon compilation.

Modifications to Standard Field Methods

The sampling plan states: "It is preferable to use fixed area plots in this study because better diameter distributions are obtained if fixed area plots are used as compared to variable radius plots." Given the importance of diameter distribution to merchantability in the problem forest types and considering the fact that variable radius plots emphasize the selection of larger stems, fixed area plots were used.

The minimum size to be measured was zero diameter breast height (dbh), that is, trees 1.34 m tall or taller.

The MoF sampling plan indicated a need to collect data on growth rates and suggests rates of basal area increase and crown characteristics as items to measure. In order to accommodate this, cruise plot methodology was expanded to collect crown ratios and diameter increments where ages are measured. Recorded for every tree was a crown ratio code indicating the ratio of live crown to total tree height. Codes were recorded as follows:

Table II.1 Crown Ratio Codes

Crown Ratio %	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81+
Code	1	2	3	4	5	6	7	8	9

Diameter increments were measured and recorded for all trees for which an age was measured. This was a minimum of two trees per plot, including the top height tree—10 per cluster.

All plots in a sample cluster are the same size. A 12-16 live tree average count per plot was required. Dead and dead potential stems were tallied.

Top height/age information was gathered on each plot, five plots per sample. Average slope (%) and aspect (azimuth) were also recorded for each plot.

MoF Audit methods were used to determine and layout the plot cluster in each sample polygon. This is a straight-forward procedure but was modified for this project in the following ways:

- The cluster consists of five full-measure fixed area plots in a pattern of one central plot and 4 plots established in cardinal directions from the initial plot. Plots falling outside the polygon are moved to a position extending past the next plot in a clockwise direction.
- Clusters in sample polygons less than 5 ha in size are established using methodology described in below.

Acceptable plot sizes are circular as follows:

Table II.2 Plot sizes

Radius (m)	Area (ha)
2.52	.002
3.99	.005
5.05	.008
5.64	.010
7.98	.020
9.77	.030
11.28	.040

Small Tree Plots

A centre nested small tree plot was added in-order to provide data on the full range of stems in the polygons down to trees 1.34-m tall. This was judged to be important given the nature of the subject stands (small diameter and/or overstocked) and given the need for full information for analysis of how these problem forest types might respond to treatments such as partial harvests.

Small tree plot radius was to be no larger than the co-incident large tree plot and chosen from the list above to include an average tree count of 12-16 live trees. Half or quarter plots were used to reduce the workload where stem counts were high.

Collected for small trees was species, height, diameter, and tree class.

Field contractor deliverables were:

- Sample cluster maps;
- Completed access notes and plot cards as per the required methodology;
- Completed polygon top height and age summary sheet; and
- Access notes and a legible and accurate photo documentation of sample location and plot layout.

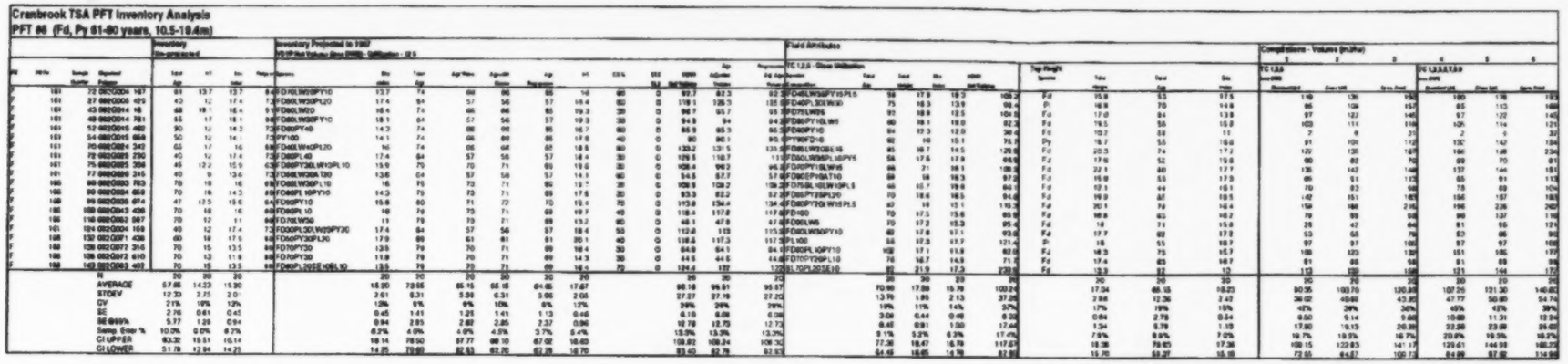
Cranbrook TSA PFT Inventory Analysis
PFT 82 (PI age >= 41years, height < 10.5m)

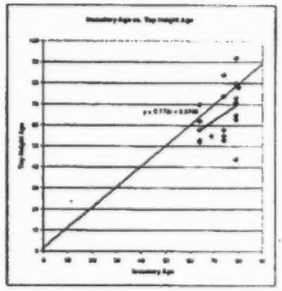
| | | |

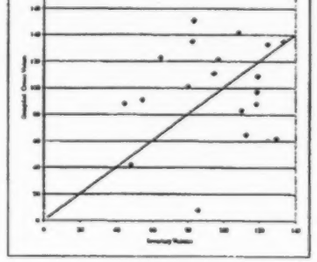
Cranbrook TSA PFT Inventory Analysis
PFT #5 (Fd, Py 41-60 years, 10.5-19.4m)

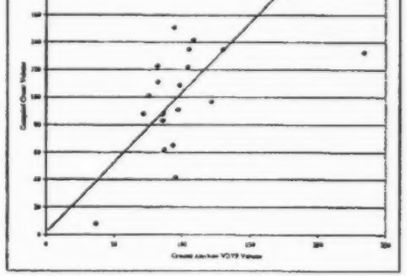
| | | |

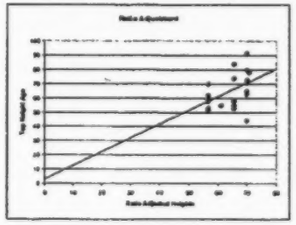
Cranbrook TSA PFT Inventory Analysis
PFT 86 (Fd, Py 51-80 years, 10.5-19.4m)

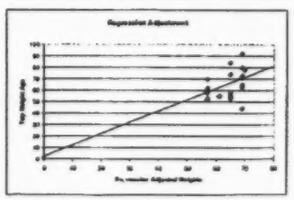


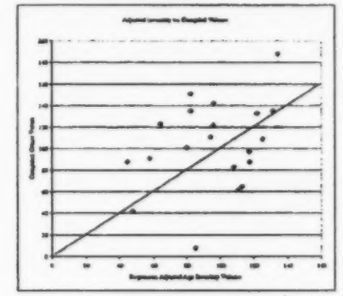












General Notes:

Projected inventory site index is always based on the age and height pair. Unprojected site index may be based on an inventory estimate.

Field Attributes are:
Species composition by compiled volume.
Heights are averages of all utilizable stems weighted by volume.

Top Height values are based on unbiased selection.

Tree Classes:
1,2,8 - fire; 5 - veteran; 3,7,9- dead potential; 6 - live useless

Utilization:
Standard - 17.5, 12.5 for Pine
Close - 12.5 all species
Special - 7.5 all species

All Volumes include any deciduous component

Cranbrook TSA PFT Inventory Analysis
PFT #7 (Fd, Py >60 years, 10.5-19.4m)

| | | |

Cranbrook TSA PFT Inventory Analysis
PFT #12 (PI 41-60 years, 10.5-19.4m)

				Inventory (Un-projected)				Inventory Projected to 1997 (VDYP Net Volume (less DWB) - Utilization - 12.5						Field Attributes								Compilations - Volume (m3/ha)					
																						1	2	3	4	5	6
PI	PFT#	Sample Number	Map sheet Polygon	Total Age	HT	Site Index	Subject	Species	Site Index	Total Age	HT	DBH	SPH	VDYP Net Volume	TC 1,2,8 - Close Utilization Species Composition	Total Age	Total Height	Site Index	VDYP Net Volume	Top Height Species	Total Height	Total Age	Site Index	TC 1,2,8 (less DWB) Standard Util.	TC 1,2,8 (less DWB) Close Util.	TC 1,2,8 (less DWB) Spec. Prod.	TC 1,2,3,4,7,8,9 (less DWB) Standard Util.	TC 1,2,3,4,7,8,9 (less DWB) Close Util.	TC 1,2,3,4,7,8,9 (less DWB) Spec. Prod.
P	188	2	082F040 68	45	16	19.2	68	PL100	19.2	54	18.3	70	0	142.9	PL80LW15SE5	54	21.1	21.9	192.6	Pl	21.6	53	22.7	360	280	368	292	309	353
P	186	4	083F030 482	46	15	18.1	68	PL100	18.1	54	17.3	70	0	126.1	PL100	60	19.1	18.7	173.7	Pl	17.9	56	18.3	290	299	397	305	305	414
P	185	7	083F068 549	39	15.2	20.4	61	PL65AT18HW14PW3	20.4	45	17.1	50	0	101.7	PD65BL10BE10PLSHW	53	20.7	22.4	168.8	Hw	17.9	60	17	210	242	277	264	333	371
P	186	14	082G002 502	12	3	16	64	PL60LW20	20.5	45	17.1	70	0	105.0	PL65LW25SE20	60	16.4	18.2	169.4	Pl	16.6	61	16.1	59	79	125	61	81	130
P	181	16	082G003 117	35	12.5	18.8	73	PL100	18.8	58	19.1	80	0	154.6	PL100	68	18	17.1	184.4	Pl	17.1	58	17.1	126	126	220	131	131	245
P	181	17	082G003 435	53	14.8	15.7	81	PL85LW5	15.7	58	15.8	80	0	119.8	PL70LW30	64	15.5	14.5	161.6	Pl	13	61	12.7	16	16	66	16	16	72
P	181	20	082G003 883	50	9.5	11.1	88	PL100	11.1	50	11	80	0	42.6	BL65PL35	76	10.6	15.7	191.7	Pl	14	66	13.8	107	108	175	125	127	196
E	188	32	082G011 376	50	13	14.7	88	PL100	14.7	59	14.8	80	0	96.6	PL45LW45SE10	54	18.6	19.5	121.6	Pl	15.7	49	17.6	143	155	231	144	154	233
E	188	33	082G011 0	59	14	15.8	88	PL90LW10	15.8	59	15.9	70	0	112	PL100	62	17.4	18.7	145.3	Pl	18.2	57	18.4	115	115	170	129	129	211
P	181	39	082G013 1938	50	16	17.8	88	PL100	17.8	58	16	80	0	102.2	PL100	64	19.8	18.6	198.6	Pl	21.3	59	21	245	245	284	306	306	376
P	181	59	082G016 849	64	12.2	13.1	93	PL100	13.1	61	13.4	70	0	79.7	PL85AC5	62	18.9	18	186.7	Pl	16.3	59	16.2	70	70	153	70	70	158
P	188	60	082G031 287	40	10	14	78	PL80BL10LW10	14	58	13.9	40	0	73.6	PL85SE15	58	18.2	18.6	137.6	Pl	18.5	52	19.9	173	181	190	176	187	198
P	188	87	082G031 941	40	11	15.2	78	PL70LW20SE10	15.2	58	15.1	80	0	85.5	PL100	60	17.6	17.4	157.6	Pl	17.8	55	18.4	255	255	324	296	296	368
P	181	101	082G057 440	38	12.2	17.3	73	PL60SE40BL20	17.3	62	18.1	50	0	152.7	PL60SE20BL18FD5	62	17.7	16.9	150.9	Pl	17.8	57	18	209	227	258	223	241	273
P	188	121	082G054 58	65	16	18.8	93	PL80FD20	18.8	62	19.5	70	0	173.9	PL100	62	18.5	17.7	184.5	Pl	20	62	19.1	130	131	146	135	136	153
P	188	131	082G071 31	50	13	14.7	88	PL80SE10LW10	14.7	59	14.8	80	0	88.5	PL100	56	16.4	12.3	138.6	Pl	18.7	56	14.2	104	104	139	104	104	142
P	188	141	082G081 659	50	14	15.8	88	PL90LW10	15.8	59	15.9	70	0	112	PL100	70	16.9	14.9	141.3	Pl	17.4	61	18.8	96	96	154	96	96	160
P	181	148	082J026 121	58	16.8	17.5	90	PL100	17.5	62	18.2	70	0	161.2	PL60SE40	58	17.9	18.3	159	Pl	18.2	49	20.3	163	177	258	176	190	269
P	181	150	082J026 487	40	10.2	14.2	78	PL100	14.2	59	14.3	70	0	83.6	PL100	68	12.8	11.8	71.6	Pl	10.1	61	9.9	17	17	57	61	61	127
P	181	153	082J048 96	40	12.2	16.8	77	PL100	16.8	60	16.9	70	0	125.3	PL95SE5	65	16.2	15	128	Pl	15.7	62	15	168	170	206	172	174	231
			N	20	20	20			20	20	20	20	20	20		20	20	20	20		20	20	20	20	20	20	20	20	20
			AVERAGE	44.55	12.92	16.23			18.45	57.60	16.23			119.19		62.40	17.82	17.21	149.06		17.19	59.10	17.14	148.70	154.45	206.30	156.70	175.40	233.90
			STDEV	9.91	3.29	2.28			2.48	4.79	2.14			38.23		8.93	1.98	2.68	31.93		2.47	8.52	3.00	80.77	85.12	85.73	90.76	94.53	98.30
			CV	22%	25%	14%			13%	8%	13%			31%		14%	10%	16%	21%		16%	14%	18%	54%	54%	42%	54%	58%	42%
			SE	2.22	0.74	0.51			0.55	1.07	0.48			7.84		2.00	0.42	0.60	7.14		0.60	1.88	0.67	18.06	18.59	19.17	20.29	21.14	21.98
			SE @95%	4.64	1.54	1.07			1.15	2.24	1.00			16.40		4.18	0.87	1.26	14.94		1.25	3.69	1.41	37.80	38.90	40.12	42.48	44.24	46.01
			Samp Error %	10.4%	11.8%	6.6%			6.7%	4.9%	7.3%			14.3%		7.3%	6.6%	7.3%	10.0%		7.3%	6.6%	8.2%	25.4%	25.2%	19.4%	25.5%	25.5%	19.7%
			CI UPPER	49.19	14.48	17.30			17.59	58.64	17.23			131.58		66.58	18.69	18.47	164.00		18.43	62.80	18.54	186.50	193.55	246.42	200.18	217.84	279.91
			CI LOWER	39.91	11.38	15.16			15.30	56.56	15.22			96.68		58.22	16.95	15.95	134.13		15.94	55.21	15.73	110.90	115.75	166.18	124.22	129.16	187.89

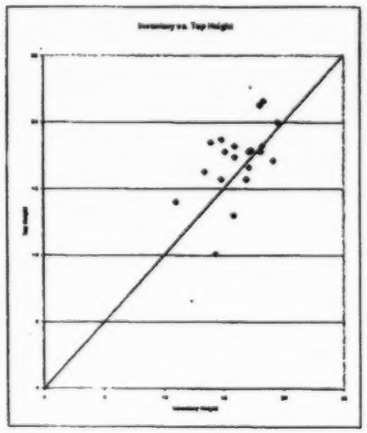
Ratio of Means
Correlation co-efficient
Variance of Ratio Estimate
SE@95%
t - test

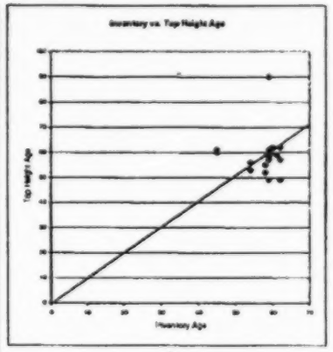
Ratio of Heights Top Ht. over Inv.	Ratio of Age Top Ht over Inv.	Ratio of SI Top Ht over Inv.
1.0682	1.0690	1.0439
0.6488	-0.0086	0.6280
0.000000000	0.001348863	0.001580361
0.0662	0.0759	0.0812
1.323493791	1.021475869	0.852219176

Ratio of Volumes Compiled over Inventory	Ratio of Volumes Compiled over Gross
1.3426	1.0275
0.3172	0.6480
0.013908199	0.013165856
0.2468	0.3403
9.370421121	1.444237868

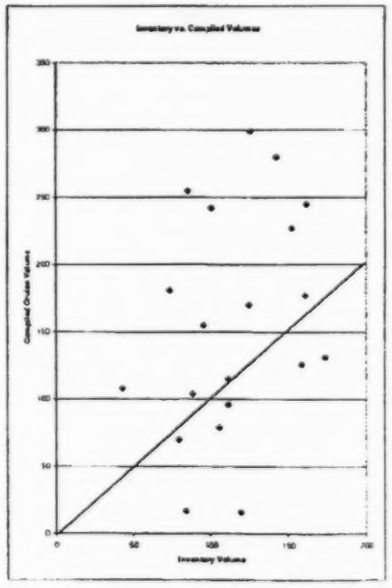
Ratio of Means
Correlation co-efficient
Variance of Ratio Estimate
SE@95%
t - test t statistic = 2.093

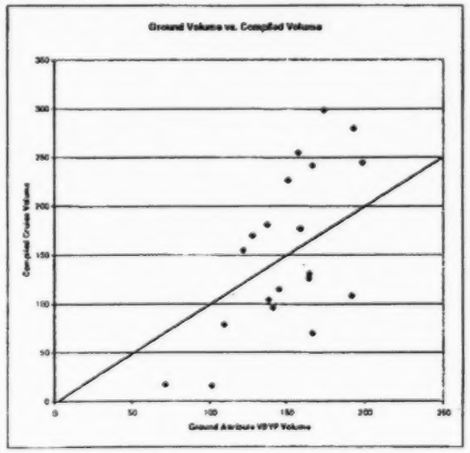
Attribute Comparisons





Volume Comparisons





General Notes:

Projected inventory site index is always based on the age and height pair.
Unprojected site index may be based on an inventory estimate.

Field Attributes are:
Species composition by compiled volume;
Heights are averages of all utilizable stems weighted by volume

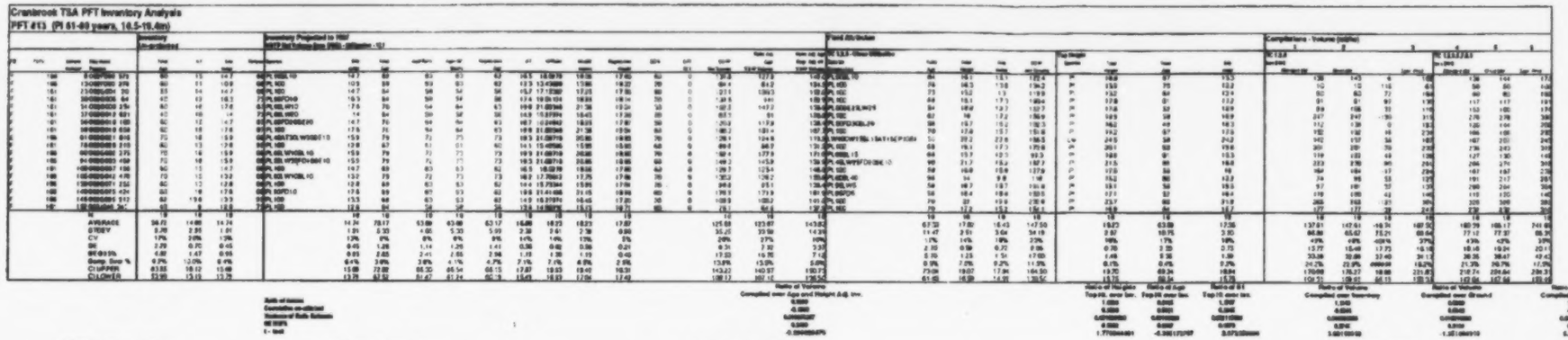
Top Height values are based on unbiased selection

Tree Classes:
1,2,8 - live; 5 - veteran; 3,7,9- dead potential; 6 - live useless

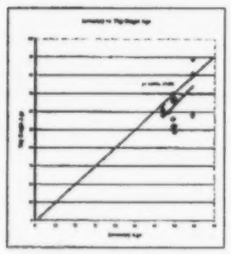
Utilization
Standard - 17.5, 12.5 for Pine
Close - 12.5 all species
Special - 7.5 all species

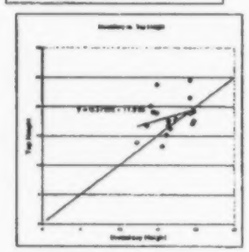
All Volumes include any deciduous component

Cranbrook TSA PFT Inventory Analysis
PFT 413 (PI 61-80 years, 10.5-10.4m)

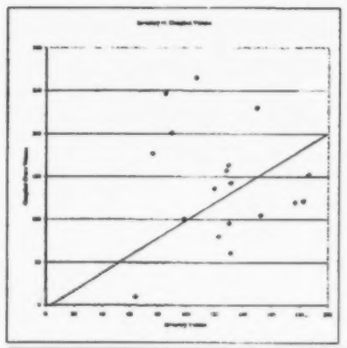


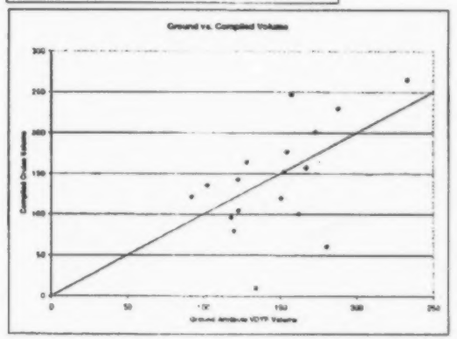
Attribute Comparisons



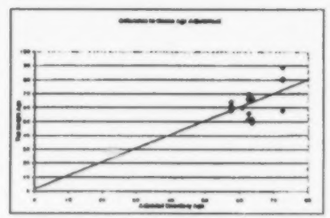


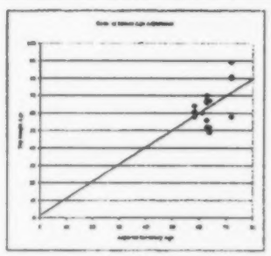
Volume Comparisons

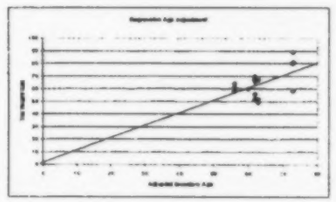


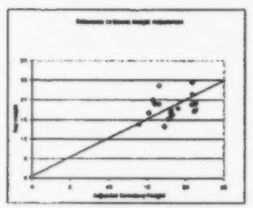


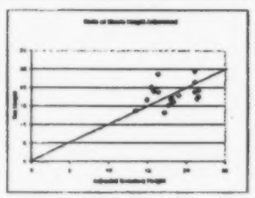
Attribute Adjustments

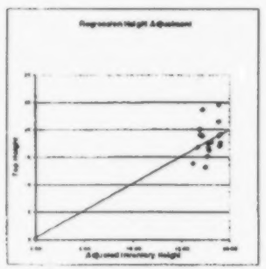




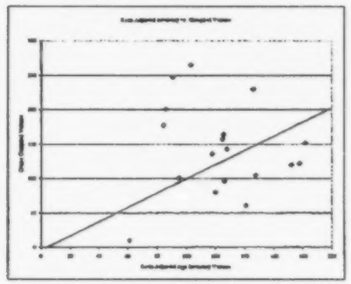


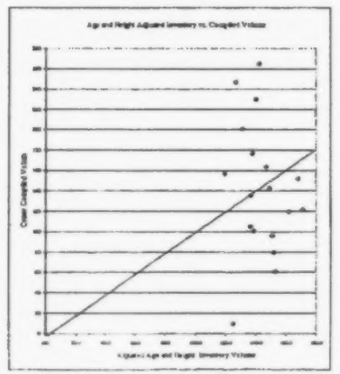






Adjusted Volume




Age and Height Adjusted Inventory vs. Coupelent Volume
Gross Compiled Volume
Adjusted Age and Height Inventory Volume

General Notes:

Projected inventory site index is always based on live age and height per
Unprojected site index may be based on an inventory estimate

Field Attributes are:
Species composition by compiled volume
Heights are averages of all utilizable stems weighted by volum

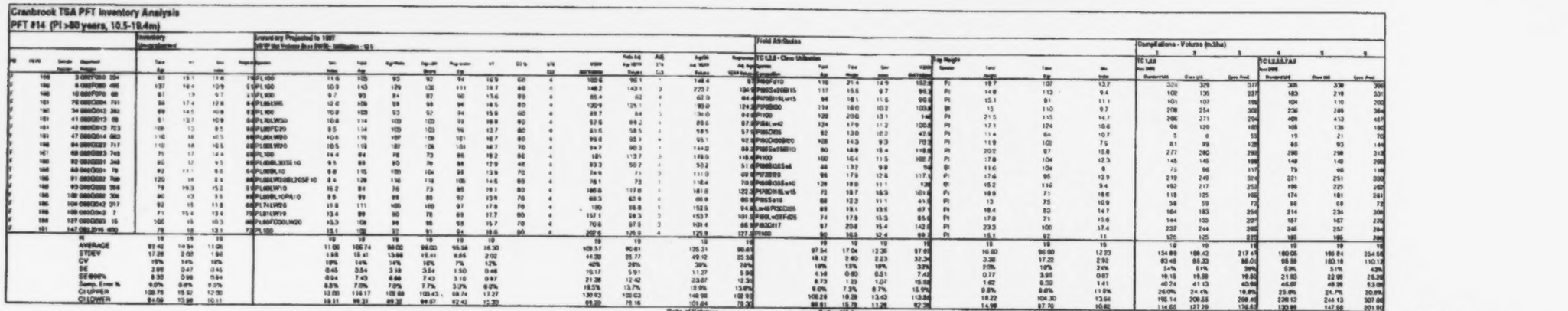
Top Height values are based on unbiased selectio

Tree Classes:
1,2,8 - live; 6 - veteran; 3,7,9- dead potential; 4 - live useless

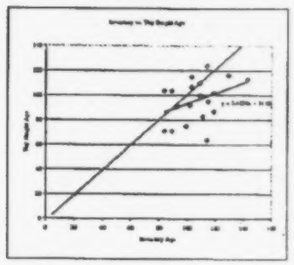
Utilizatior
Standard - 17.5, 12.5 for Pine
Close - 12.5 all species
Special - 7.5 all species

All Volumes include any deciduous componer

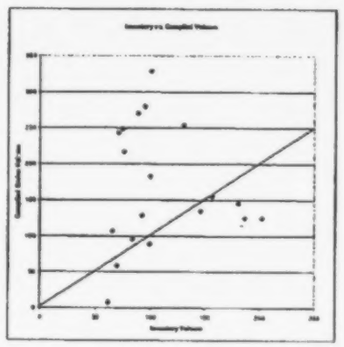
Cranbrook TSA PFT Inventory Analysis
PFT #14 (Pl >80 years, 10.5-18.4m)

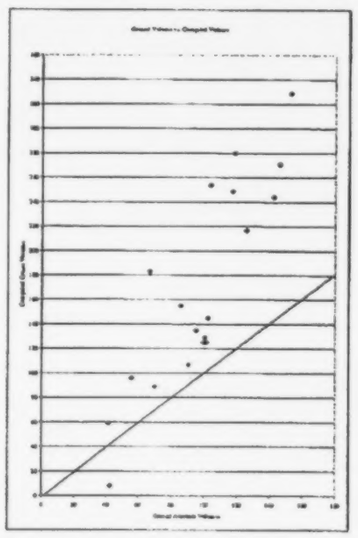


Age Comparison

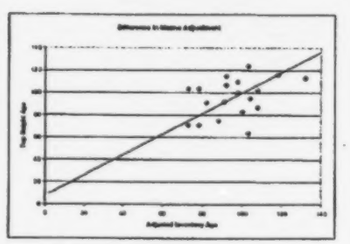


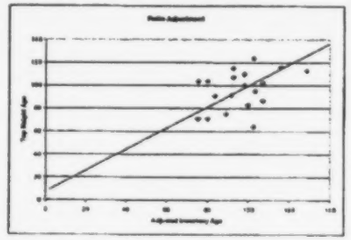
Volume Comparisons

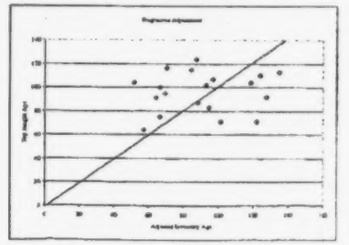




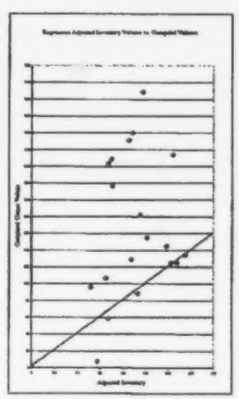
Age Adjustments







Adjusted Volumes



General Notes:

Projected inventory site index is always based on the age and height pair
Unprojected site index may be based on an inventory estimate.

Field Attributes are:
Species composition by compiled volume;
Heights are averages of all utilizable stems weighted by volume

Top Height values are based on unbiased selection

Tree Classes:
1,2,8 - live; 5 - veteran; 3,7,9- dead potential; 6 - live useless

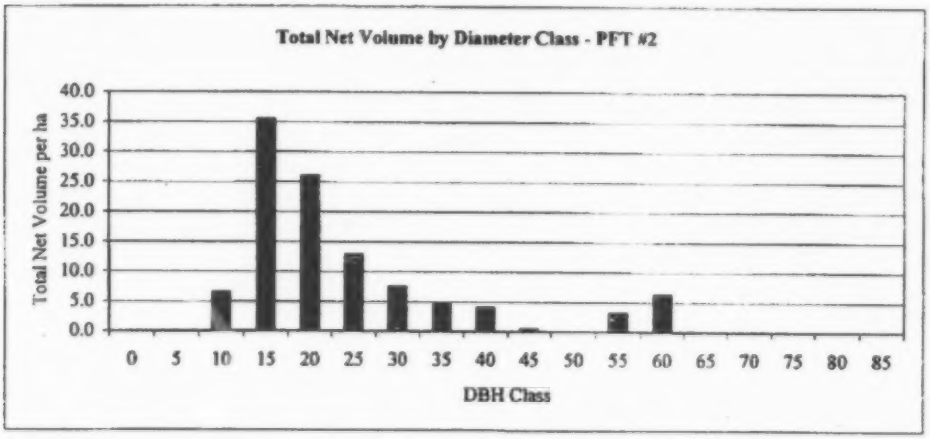
Utilization:
Standard 17.5, 12.5 for Pine
Close - 12.5 all species
Special - 7.5 all species

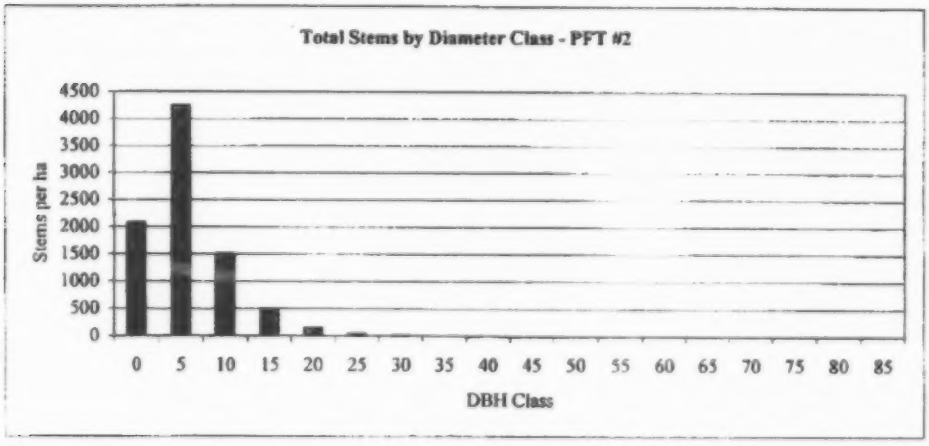
All Volumes include any deciduous component

APPENDIX IV – PFT STAND AND STOCK SUMMARIES

PFT #2 (Pl age >= 41years, height < 10.5m)

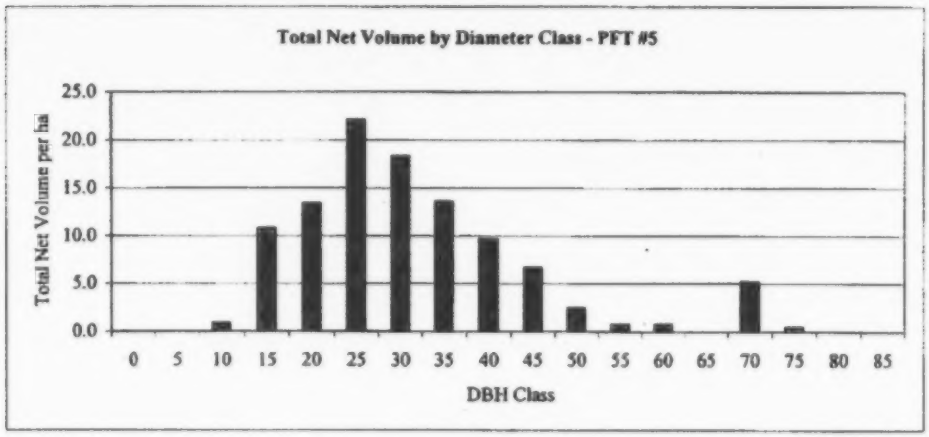
	Volume			Stems		
DBH Class	Total Net Volume	Percent of Total	Percent this DBH Class or Greater	Total Stems/ha	Percent of Total	Percent this DBH Class or Greater
0	0.0	0.0	100.0	2084.6	24.4	100.0
5	0.0	0.0	100.0	4249.2	49.6	75.6
10	6.5	6.1	100.0	1504.9	17.6	26.0
15	35.5	33.1	93.9	499.7	5.8	8.4
20	26.0	24.3	60.8	150.5	1.8	2.6
25	12.9	12.0	36.5	42.2	0.5	0.8
30	7.5	7.0	24.5	15.1	0.2	0.3
35	4.6	4.3	17.5	6.0	0.1	0.2
40	4.1	3.8	13.2	3.8	0.0	0.1
45	0.5	0.5	9.3	0.4	0.0	0.0
50	0.0	0.0	8.9	0.0	0.0	0.0
55	3.2	3.0	8.9	1.3	0.0	0.0
60	6.3	5.9	5.9	2.4	0.0	0.0
65	0.0	0.0	0.0	0.0	0.0	0.0
70	0.0	0.0	0.0	0.0	0.0	0.0
75	0.0	0.0	0.0	0.0	0.0	0.0
80	0.0	0.0	0.0	0.0	0.0	0.0
85	0.0	0.0	0.0	0.0	0.0	0.0
Total	107.1	100.0		8560.1	100.0	

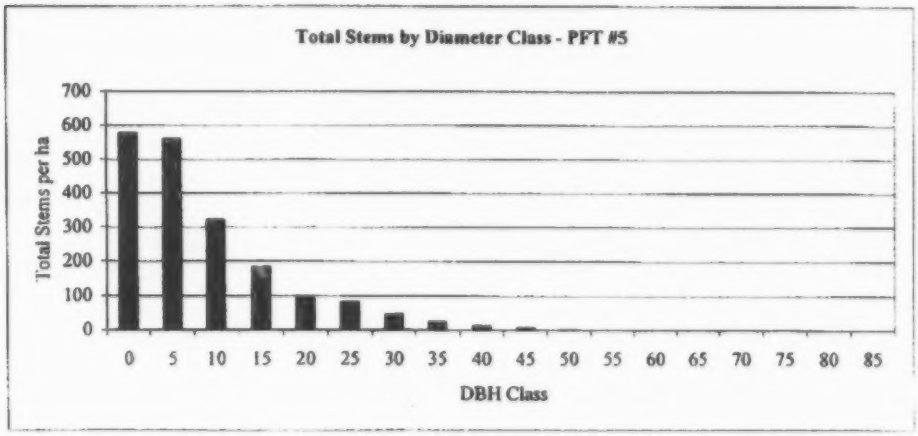




PFT #5 (Fd, Py 41-60 years, 10.5-19.4m)

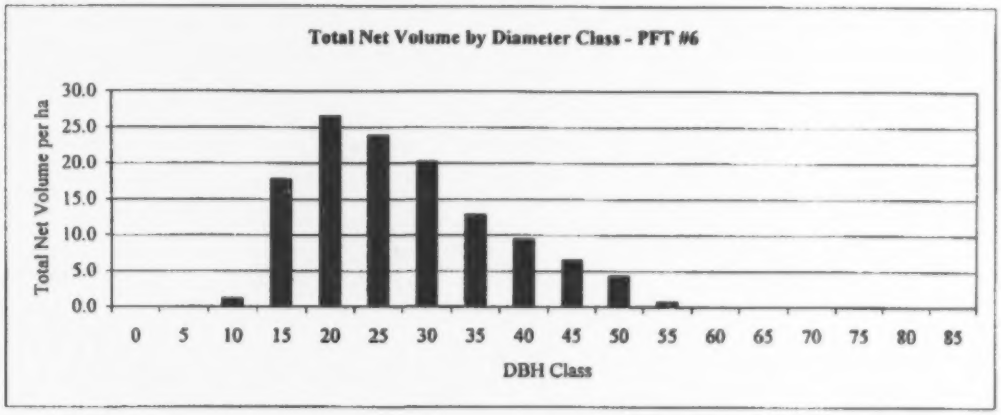
	Volume			Stems		
DBH Class	Total Net Volume	Percent of Total	Percent this DBH Class or Greater	Total Stems/ha	Percent of Total	Percent this DBH Class or Greater
0	0.0	0.0	100.0	577.6	30.2	100.0
5	0.0	0.0	100.0	559.4	29.3	69.8
10	0.9	0.9	100.0	320.5	16.8	40.5
15	10.8	10.3	99.1	183.9	9.6	23.7
20	13.4	12.7	88.9	93.4	4.9	14.0
25	22.1	21.0	76.2	82.2	4.3	9.2
30	18.3	17.4	55.2	45.9	2.4	4.9
35	13.6	12.9	37.8	23.8	1.2	2.5
40	9.7	9.2	24.9	12.5	0.7	1.2
45	6.7	6.4	15.7	6.0	0.3	0.5
50	2.5	2.4	9.3	2.0	0.1	0.2
55	0.8	0.8	6.9	0.6	0.0	0.1
60	0.8	0.8	6.2	0.4	0.0	0.1
65	0.0	0.0	5.4	0.0	0.0	0.1
70	5.2	4.9	5.4	1.1	0.1	0.1
75	0.5	0.5	0.5	0.4	0.0	0.0
80	0.0	0.0	0.0	0.0	0.0	0.0
85	0.0	0.0	0.0	0.0	0.0	0.0
Total	105.3	100.0		1909.7	100.0	

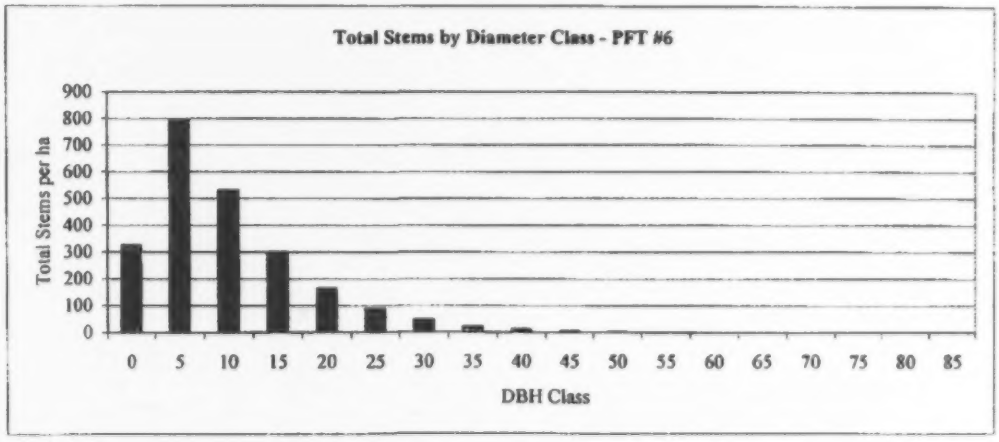

Total Net Volume by Diameter Class - PFT #5
Total Net Volume per ha
25.0
20.0
15.0
10.0
5.0
0.0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85
DBH Class



PFT #6 (Fd, Py 61-80 years, 10.5-19.4m)

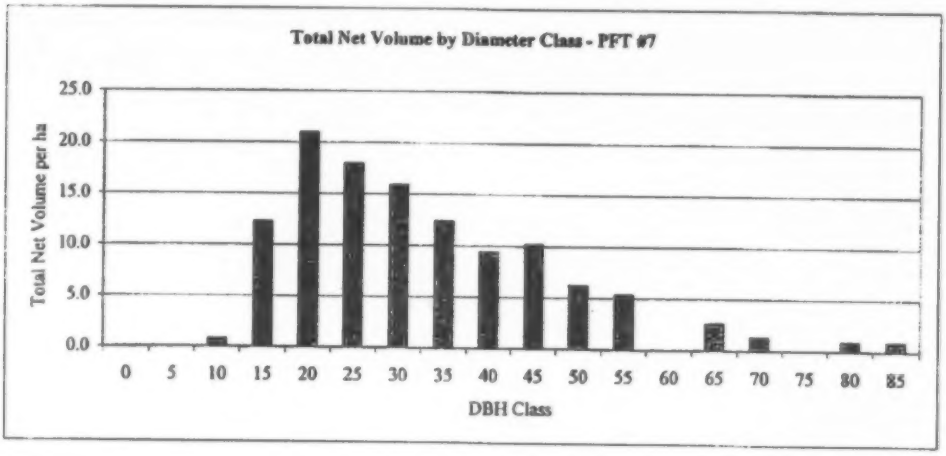
	Volume			Stems		
DBH Class	Total Net Volume	Percent of Total	Percent this DBH Class or Greater	Total Stems/ha	Percent of Total	Percent this DBH Class or Greater
0	0.0	0.0	100.0	325.2	14.2	100.0
5	0.0	0.0	100.0	796.4	34.7	85.8
10	1.1	0.9	100.0	531.6	23.2	51.1
15	17.7	14.4	99.1	300.3	13.1	28.0
20	26.5	21.6	84.7	164.4	7.2	14.9
25	23.8	19.4	63.1	88.9	3.9	7.7
30	20.1	16.4	43.8	46.3	2.0	3.9
35	12.8	10.4	27.4	20.4	0.9	1.8
40	9.4	7.6	17.0	12.4	0.5	1.0
45	6.5	5.3	9.4	5.8	0.3	0.4
50	4.3	3.5	4.1	3.2	0.1	0.2
55	0.7	0.6	0.6	0.5	0.0	0.0
60	0.0	0.0	0.0	0.0	0.0	0.0
65	0.0	0.0	0.0	0.0	0.0	0.0
70	0.0	0.0	0.0	0.0	0.0	0.0
75	0.0	0.0	0.0	0.0	0.0	0.0
80	0.0	0.0	0.0	0.0	0.0	0.0
85	0.0	0.0	0.0	0.0	0.0	0.0
Total	**122.9**	**100.0**		**2295.4**	**100.0**	

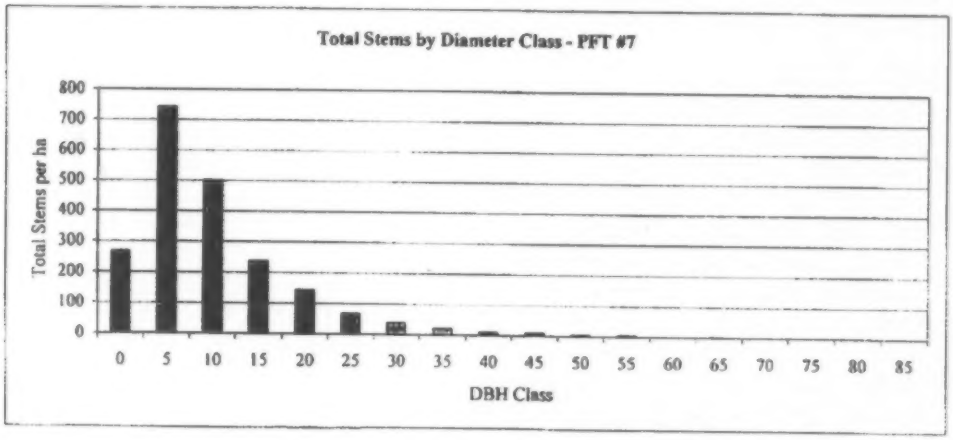




PFT #7 (Fd, Py >80 years, 10.5-19.4m)

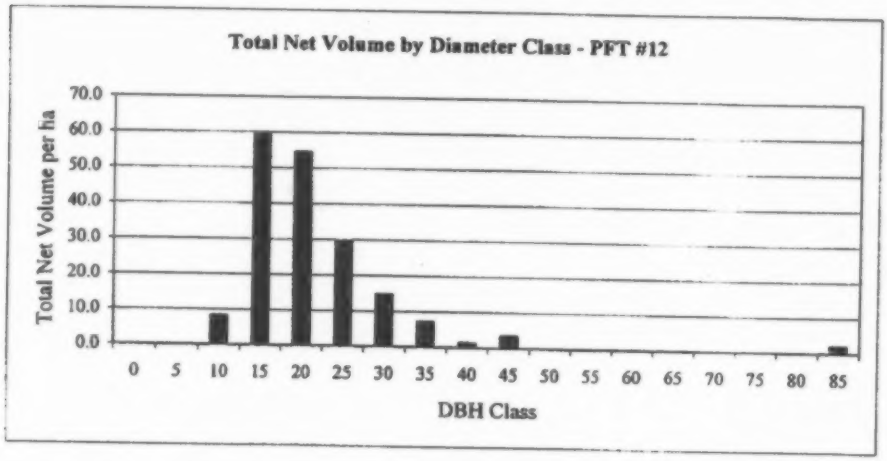
	Volume			Stems		
DBH Class	Total Net Volume	Percent of Total	Percent this DBH Class or Greater	Total Stems per ha	Percent of Total	Percent this DBH Class or Greater
0	0.0	0.0	100.0	267.9	13.1	100.0
5	0.0	0.0	100.0	741.8	36.2	86.9
10	0.8	0.7	100.0	499.5	24.4	50.7
15	12.3	10.5	99.3	238.0	11.6	26.3
20	21.0	17.9	88.8	144.3	7.0	14.7
25	18.0	15.4	70.9	67.9	3.3	7.6
30	15.9	13.6	55.5	37.9	1.9	4.3
35	12.4	10.6	42.0	21.4	1.0	2.5
40	9.4	8.0	31.4	10.3	0.5	1.4
45	10.2	8.7	23.4	8.9	0.4	0.9
50	6.2	5.3	14.7	4.7	0.2	0.5
55	5.3	4.5	9.4	3.1	0.2	0.2
60	0.0	0.0	4.9	0.0	0.0	0.1
65	2.6	2.2	4.9	1.1	0.1	0.1
70	1.3	1.1	2.6	0.4	0.0	0.0
75	0.0	0.0	1.5	0.0	0.0	0.0
80	0.9	0.8	1.5	0.2	0.0	0.0
85	0.9	0.8	0.8	0.2	0.0	0.0
Total	117.2	100.0		2047.6	1747.1	

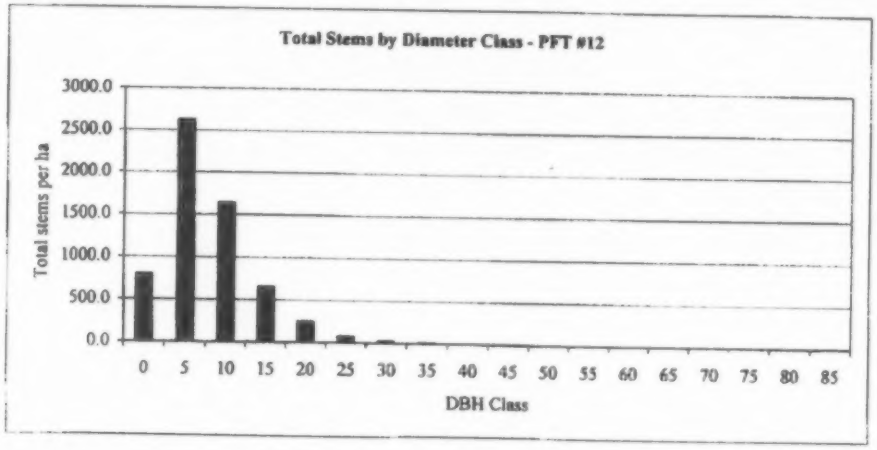

Total Net Volume by Diameter Class - PFT #7
Total Net Volume per ha
25.0
20.0
15.0
10.0
5.0
0.0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85
DBH Class



PFT #12 (Pl 41-60 years, 10.5-19.4m)

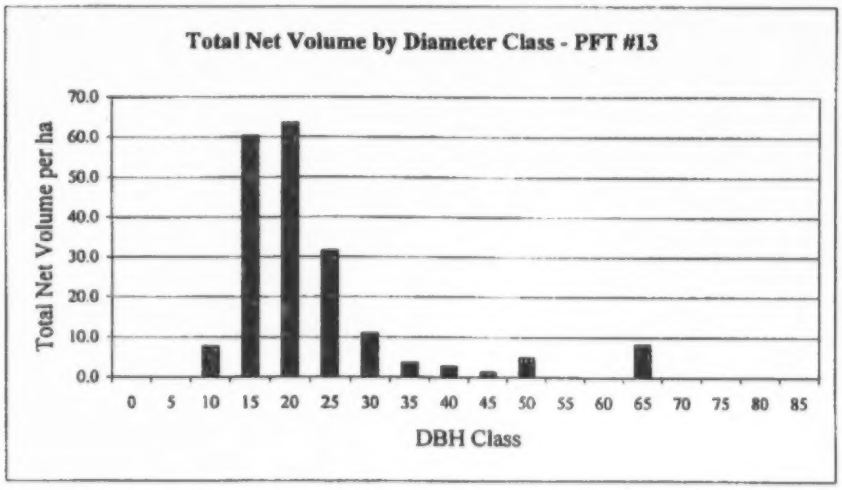
DBH Class	Volume			Stems		
	Total Net Volume	Percent of Total	Percent this DBH Class or Greater	Total Stems/ha	Percent of Total	Percent this DBH Class or Greater
0	0.0	0.0	100.0	795.4	13.1	100.0
5	0.0	0.0	100.0	2621.1	43.1	86.9
10	8.3	4.6	100.0	1642.3	27.0	43.9
15	59.1	32.7	95.4	651.3	10.7	16.9
20	54.5	30.2	62.7	250.5	4.1	6.2
25	29.7	16.4	32.5	80.2	1.3	2.1
30	14.9	8.3	16.1	29.4	0.5	0.8
35	7.2	4.0	7.8	10.3	0.2	0.3
40	1.3	0.7	3.8	1.3	0.0	0.1
45	3.5	1.9	3.1	2.6	0.0	0.1
50	0.0	0.0	1.2	0.0	0.0	0.0
55	0.0	0.0	1.2	0.0	0.0	0.0
60	0.0	0.0	1.2	0.0	0.0	0.0
65	0.0	0.0	1.2	0.0	0.0	0.0
70	0.0	0.0	1.2	0.0	0.0	0.0
75	0.0	0.0	1.2	0.0	0.0	0.0
80	0.0	0.0	1.2	0.0	0.0	0.0
85	2.1	1.2	1.2	2.1	0.0	0.0
Total	**180.6**	**100.0**		**6084.5**	**100.0**	

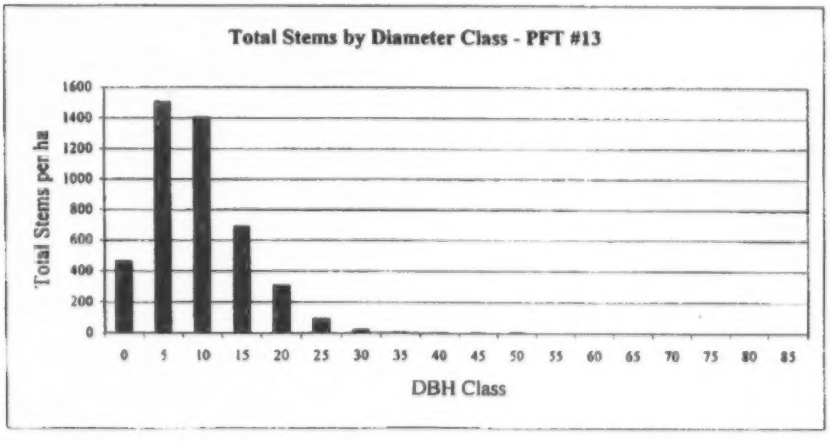




PFT #13 (Pl 61-80 years, 10.5-19.4m)

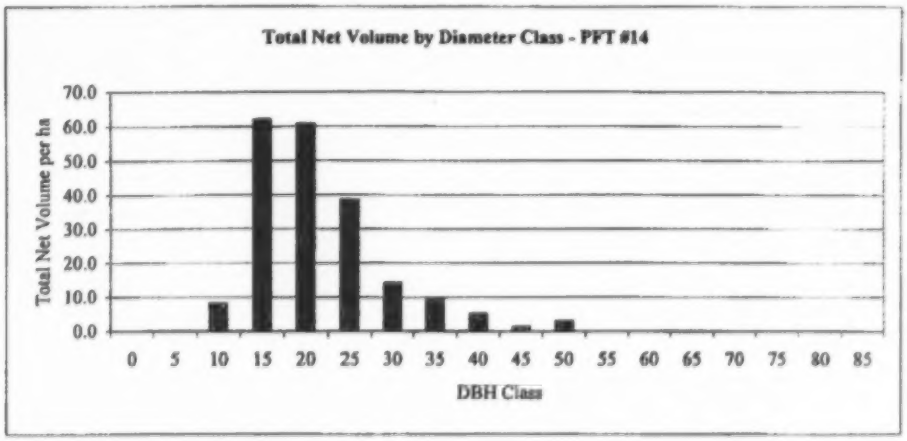
	Volume			Stems		
DBH Class	Total Net Volume	Percent of Total	Percent this DBH Class or Greater	Total Stems/ha	Percent of Total	Percent this DBH Class or Greater
0	0.0	0.0	100.0	464.4	10.3	100.0
5	0.0	0.0	100.0	1507.2	33.5	89.7
10	7.6	3.9	100.0	1403.7	31.2	56.2
15	60.4	31.0	96.1	688.4	15.3	25.0
20	63.5	32.6	65.1	306.0	6.8	9.7
25	31.5	16.2	32.4	93.8	2.1	2.9
30	10.9	5.6	16.2	22.4	0.5	0.8
35	3.7	1.9	10.6	4.5	0.1	0.3
40	2.6	1.3	8.7	2.8	0.1	0.2
45	1.3	0.7	7.4	1.1	0.0	0.2
50	4.9	2.5	6.7	3.7	0.1	0.1
55	0.0	0.0	4.2	0.0	0.0	0.1
60	0.0	0.0	4.2	0.0	0.0	0.1
65	8.2	4.2	4.2	2.3	0.1	0.1
70	0.0	0.0	0.0	0.0	0.0	0.0
75	0.0	0.0	0.0	0.0	0.0	0.0
80	0.0	0.0	0.0	0.0	0.0	0.0
85	0.0	0.0	0.0	0.0	0.0	0.0
Total	194.6	100.0		4500.3	100.0	

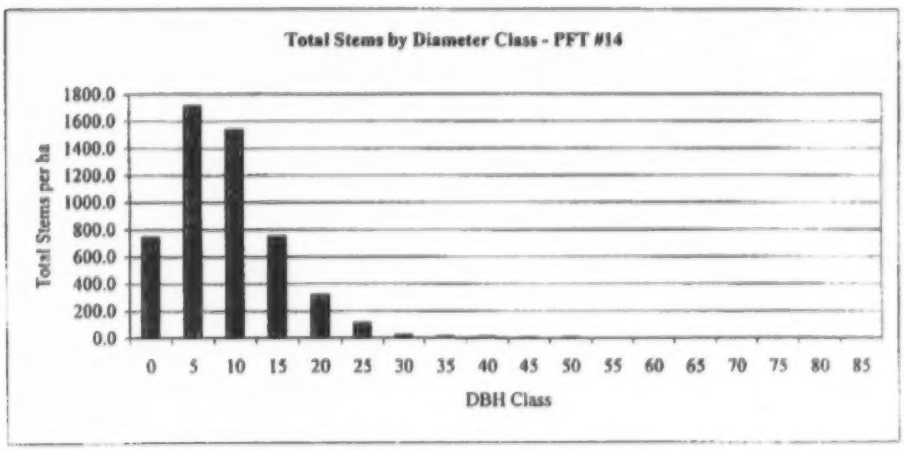




PFT #14 (Pl >80 years, 10.5-19.4m, stocking class 4)

	Volume			Stems		
DBH Class	Total Net Volume	Percent of Total	Percent this DBH Class or Greater	Total Stems/ha	Percent of Total	Percent this DBH Class or Greater
0	0.0	0.0	100.0	748.9	14.3	100.0
5	0.0	0.0	100.0	1713.5	32.8	85.7
10	8.2	4.0	100.0	1334.6	29.4	52.9
15	62.1	30.6	96.0	749.7	14.4	23.5
20	60.7	29.9	65.3	316.9	6.1	9.1
25	38.6	19.0	35.4	111.5	2.1	3.1
30	14.1	7.0	16.3	25.3	0.5	0.9
35	9.5	4.7	9.4	15.2	0.3	0.5
40	5.1	2.5	4.7	5.1	0.1	0.2
45	1.4	0.7	2.2	1.1	0.0	0.1
50	3.0	1.5	1.5	2.2	0.0	0.0
55	0.0	0.0	0.0	0.0	0.0	0.0
60	0.0	0.0	0.0	0.0	0.0	0.0
65	0.0	0.0	0.0	0.0	0.0	0.0
70	0.0	0.0	0.0	0.0	0.0	0.0
75	0.0	0.0	0.0	0.0	0.0	0.0
80	0.0	0.0	0.0	0.0	0.0	0.0
85	0.0	0.0	0.0	0.0	0.0	0.0
Total	202.7	100.0		5224.0	100.0	





APPENDIX V - SAMPLE LOCATION MAPS